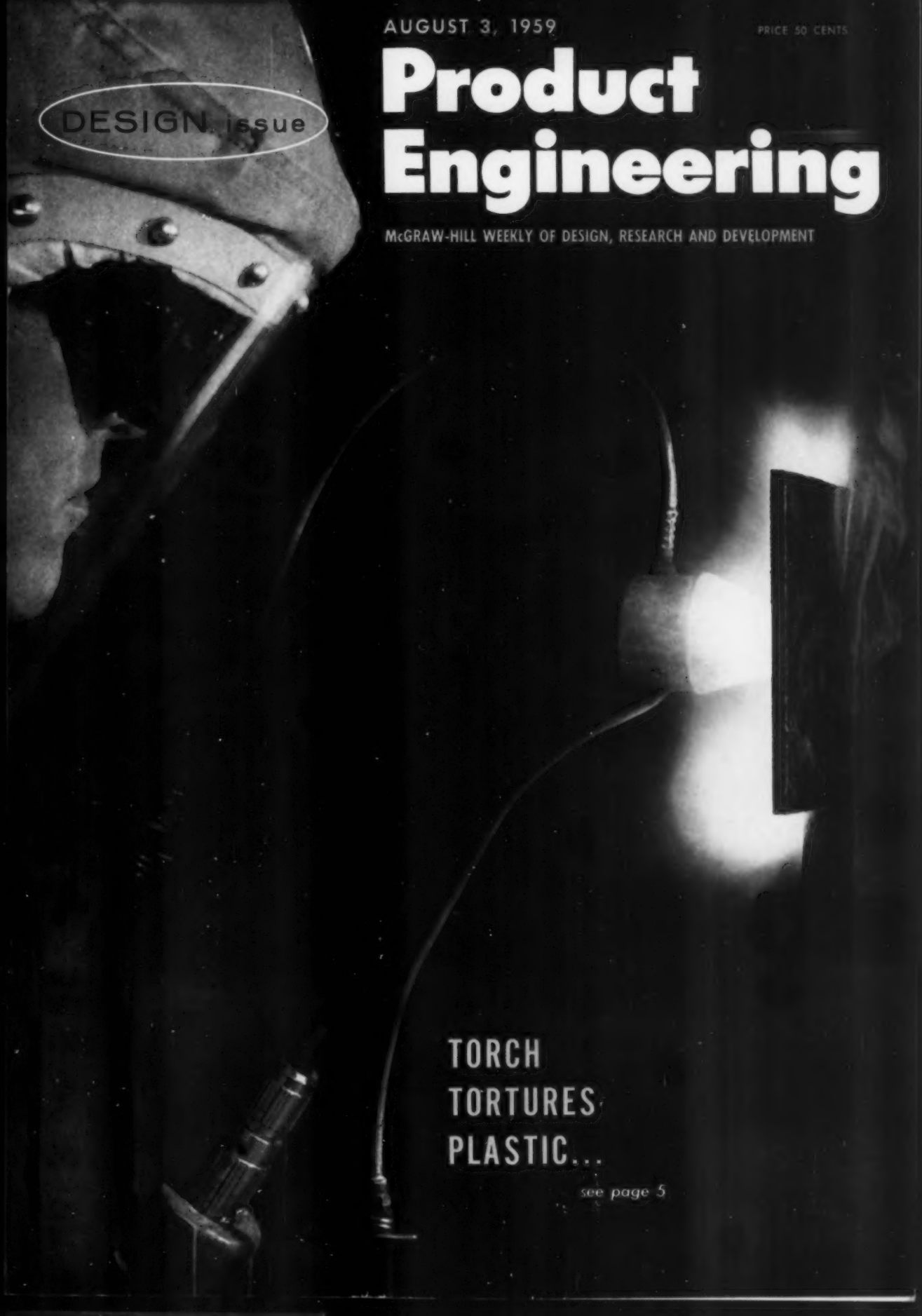
AUGUST 3, 1959

PRICE 50 CENTS

DESIGN issue

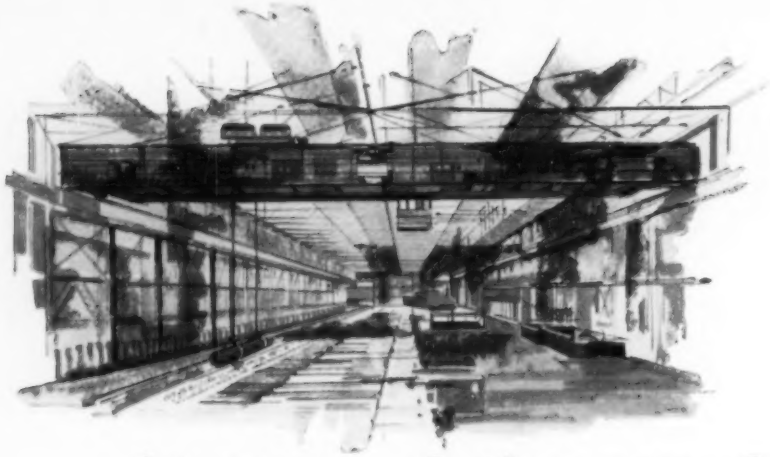
Product Engineering

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT



TORCH TORTURES PLASTIC...

see page 5



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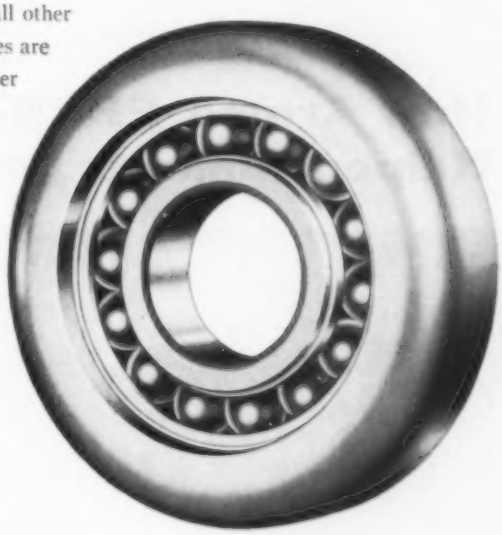

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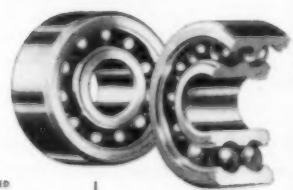
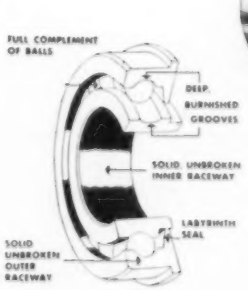
. . Medium sizes or sizes to 2″ diameter and over

Bearings with flanged outer members in all sizes



Double row type bearings.



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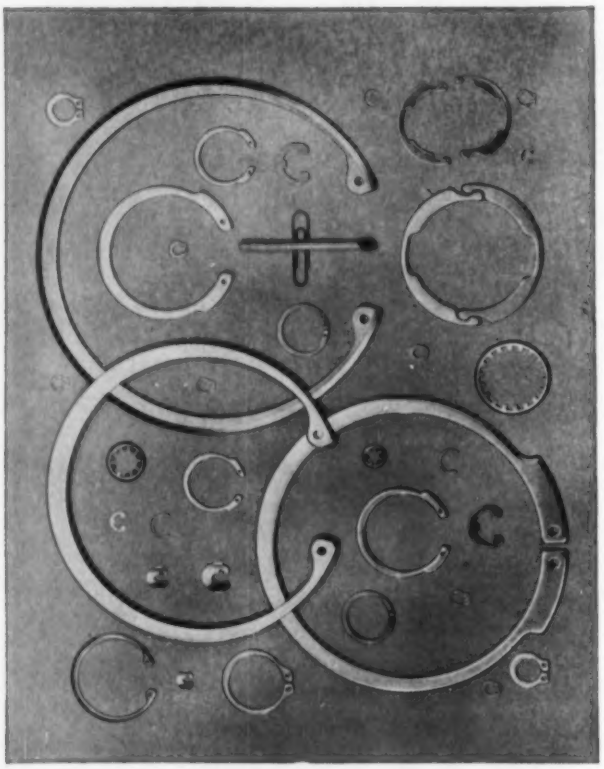

reactors, appliances; marine equipment; and other applications subject to severe service conditions.

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Product Engineering

McGRAW-HILL WEEKLY OF DESIGN RESEARCH AND DEVELOPMENT

DESIGN issue

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Interesting to Note . . .

Test by Fire

Mythology tells us that fire was given to man by the giant Prometheus, so man could presumably raise himself to the level of the gods. As a result, Prometheus was punished by Zeus who ordered him chained to a rock where his liver was gnawed daily by a vulture. He was freed from this unpleasant fate when Hercules killed the vulture.

Actually, man first saw fire during the natural action of lightning, earthquake and volcanic activity. In time he learned how to produce his own controllable flame for heat, light and cooking by using flint and iron, later various friction devices such as the bow drill or popgun. Among today's societies, only the inhabitants of the Andaman Islands off India have no apparent method of making fire. They are dependent on the maintenance of a continual flame.

But fire can be damaging as well as helpful, and the search for fire-resistant materials and design techniques never ends. The article on page 38 describes current developments in "flameproofing" and tests for flame-resistant materials. One test by fire is the oxy-acetylene torch test shown on our cover. Conducted by the Continental-Diamond Fibre Corp, a Budd Co subsidiary in Newark, Del, these tests help produce reinforced-plastic heat-barrier and structural parts for missiles that will withstand high temperatures for a few seconds. Test temperatures here are about 5000 F. An optical pyrometer measures surface temperature, and the torch itself is watercooled to prevent blowback. Burn-through time and weight loss of the specimen are measured and the mechanism of surface disintegration is examined by telescope during ablation.

What the Greeks Knew About Gears

Breakthroughs in science are commonplace today. It seems almost a daily occurrence to read that man has gone higher or faster. Our scientific advance often overshadows historical discoveries. At the annual meeting of the American Association for the Advancement of Science, one such "historical breakthrough" was revealed last December (*PE—Feb 2, p 39*).

Dr Derek J de Solla Price, a fellow of the Institute for Advanced Study at Princeton, made announcement of the finding of an ancient Greek assembly of dials and gears used for calculating the

(CONTINUED ON PAGE 7)

Product Engineering
A McGRAW-HILL PUBLICATION

August 3, 1959, Vol. 30, No. 31

PRODUCT ENGINEERING is published weekly, with an additional Design Digest Issue in Mid-September, by McGraw-Hill Publishing Company Inc., James H. McGraw (1860-1948), Founder. PUBLICATION OFFICE, 99-129 North Broadway, Albany 1, N. Y. See panel right for directions regarding subscription or change of address. EXECUTIVE, EDITORIAL, CIRCULATION and ADVERTISING OFFICES: 330 W. 42nd St., New York 36, N. Y. Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice-President; L. Keith Goodrich, Vice-President and Treasurer; John J. Cooke, Secretary. Officers of the Publications Division: Nelson L. Bond, President; Harry L. Waddell, Senior Vice-President; Ralph B. Smith, Vice-President and Editorial Director; Joseph H. Allen, Vice-President and Director of Advertising Sales; A. R. Venezian, Vice-President and Circulation Coordinator.

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Tiny Living Heat Exchangers. Some species of deep sea fish have countercurrent bundles of blood vessels (rete mirabile, shown twice actual size) so efficient that if boiling water and ice water were counterflowing in them, heat transfer would be complete to 1/10,000 of a degree!

Miniature Pressure Transducer for airborne instrumentation, 1″ long, 1″ O.D., withstands accelerations in 3 planes up to 40g with error less than 1%. Utilizing low-torque characteristics, 2 MPB bearings provide capacity, life and maintain exacting precision of a sensitive linkage.

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Man is making fabulous progress in his ceaseless fight against friction and inertia. Today's machines operate at fantastic speeds and accelerations . . . on earth . . . in the sky . . . and beyond. But space for components daily becomes more precious and while bearings used in these machines must have tremendous stamina, many of them must be almost unbelievably compact. MPB makes over 500 types and sizes of such bearings ranging down to 1/10″ O.D. Send for illustrated catalog describing them. Special bearings supplied when necessary. Design assistance at your request. Write **Miniature Precision Bearings, Inc., 209** Precision Park, Keene, N. H.

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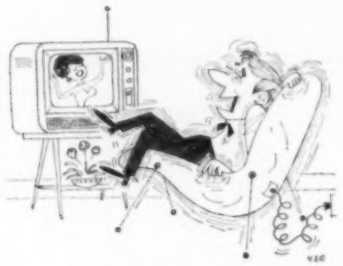
positions of the major astronomical bodies. What made his machine so unusual was that it showed the Greeks had achieved a level of scientific sophistication not to be matched by other Europeans for 1700 years. The planetarium was actually built about 85 BC. The complex use of gears (p 59) was known to exist during the 18th century but, says Dr Price, "the discovery of the planetarium in a Greek wreck is the equivalent of opening up an ancient Egyptian tomb and finding an atomic pile inside."

In the June issue of *Scientific American*, *Dr Price* described the artifact, "It has two scales, one of which is fixed and displays the signs of the zodiac; the other is on a movable slip ring and shows the months of the year. The back dials are more complex, one with three exquisitely calibrated slip rings and the other with four. These show the phases of the 'moon (so many hours), and sun (so many hours),' including rising and setting times. The dials also present information on the risings and settings, stations and retrogradations of all planets known to the Greeks as well as the more prominent constellations. The inscriptions on the cover mention the sun several times and one line significantly records '76 years, 19 years.' This refers to the well-known Calippic cycle of 76 years which is four times the Metonic cycle of 19 years, or 235 synodic (lunar) months. The next line includes the number '223' which refers to the eclipse cycle of 223 lunar months."

All Shook Up



Home vibrators seem to be one of our fastest growing fads. Hand vibrators have been used by barbers for years, but now they can be bought in shoe stores, department stores and hardware shops. Even your local druggist carries some sort of vibrating machine. Bed pads will shake you to sleep; TV addicts are literally rocked senseless while pretzel-bent in their contour chairs. Be it tired blood or tired bones, electric vibrators are advertised to rejuvenate any portion of the anatomy.

While vibration is being brought into the home, designers are trying to find a way to eliminate it from their products (p 48). During the war, vibration tests were made on planes, ships and tanks. These data, however, did not include sufficient information on man's performance under vibration, especially with regards to drivers of rubber-tired trucks. The Army Office of the Surgeon General asked the Bostrom Research Laboratories in Milwaukee to study the effects on vehicular vibration. Dr Melvin A Schmitz, chief engineering psychologist, recently made his report.

According to Dr Schmitz, truck and tractor drivers may have their visual acuity impaired up to 20%; ability to perceive depth, balance oneself and keep a constant foot pressure may also be impaired. When man sits on a vibrating source, says Dr Schmitz, he deprives himself of a natural vibration isolator, his legs and feet.

Pony Express

When the first shots were fired at Concord and Lexington that mid-April day in 1775, news was immediately dispatched to southern cities. At mid-day, four days after the Revolutionary War began, citizens in New York City heard the news. It took nine days for the news to reach Virginia and fifteen days before the people at Charleston knew the fight for independence had begun. The slowness of sending messages overland had been a constant headache all over the world, with the best solution being runners or horsemen in relays.

Thomas Gilcrease Institute of American History and Art.

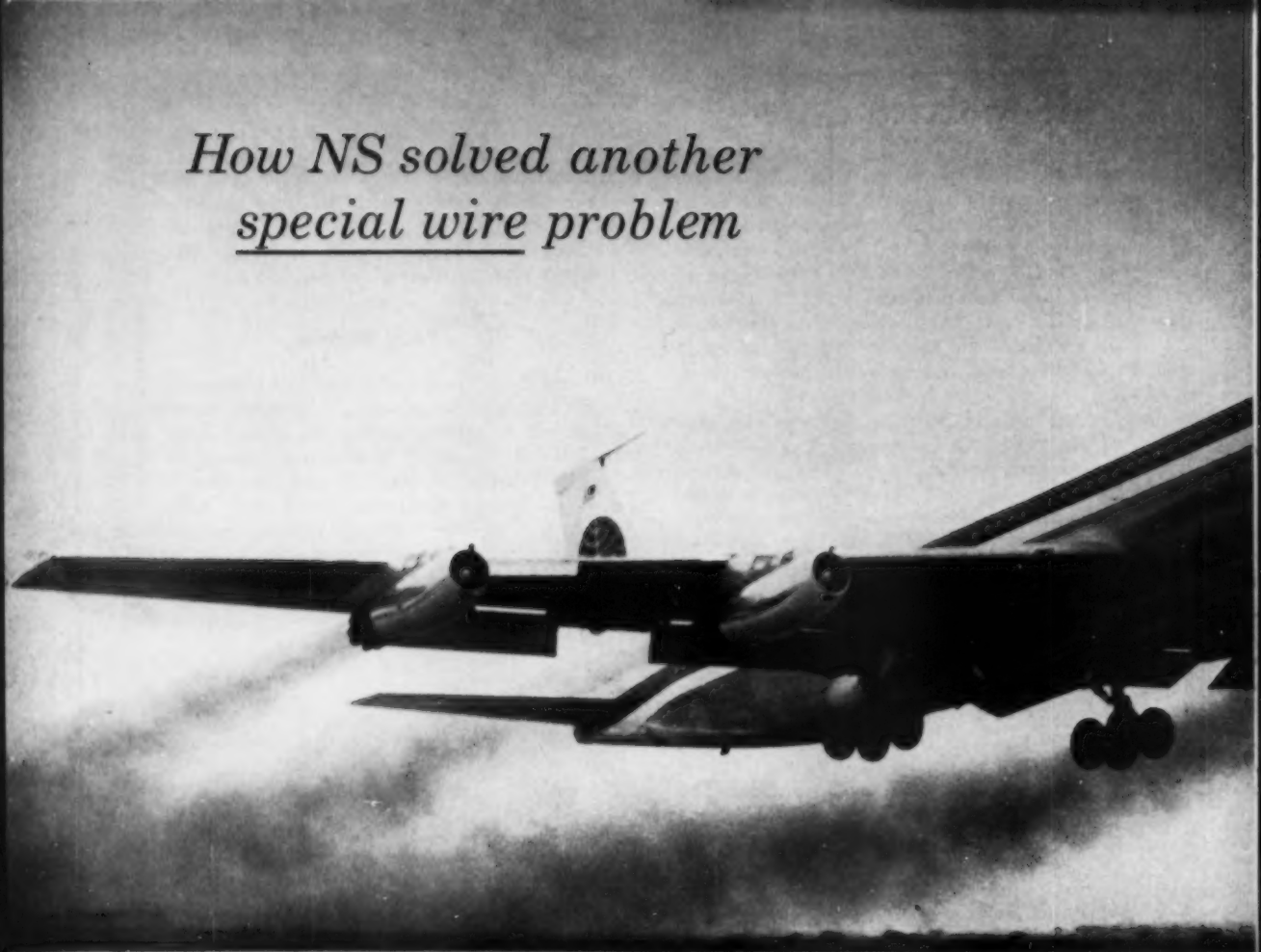
The Coming and Going of the Pony Express, *by Frederic Remington*

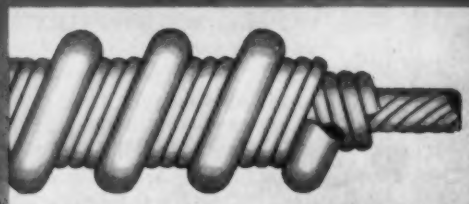
Thus, in 1860, the Pony Express was inaugurated in Western US. It was not a government-operated mail route, but a commercial venture undertaken by the freighting firm, Russell, Majors & Waddell. Eighty riders (average age, 18) were hired to carry messages; 190 stations were built and 500 horses were purchased. Rates started at $5 a half ounce, but were soon reduced to a dollar. On April 3, the first rider headed West from St Joseph, Mo. By changing horses and riders at set intervals, the message pouch could be carried 250 miles a day and on April 13 a rider entered Sacramento. This was the fastest delivery system ever devised.

However, with the invention of telegraphy, the Pony Express was doomed. By 1861, Western Union had extended its lines westward and the oncoming Civil War made the growth of this faster means of communication a necessity. When the last rider rode to Sacramento in the fall of 1861, the company went out of business with a net loss of $200,000. Western Union's latest development (p 44) is a machine that rapidly sends pictures by wire without rolling, spindling or clamping the photo to a mandrel. What it took man and beast ten days to do less than a century ago can now be done in seconds.

—Benedich A Leerburger Jr

How NS solved another special wire problem





REMOTE CONTROL cable for jet aircraft is made of layers of high-tensile National-Standard wire wound around a stranded core. Heavy outer wire provides helix or worm-gear surface for meshing with hobbed wheels.

Photo courtesy Pan American Airlines

Special National-Standard wire helps fly new jet-liners

When the age of commercial jet transportation in the U.S. began last January, giant jet-liners inaugurated flights across the country at speeds over 600 mph. To control these new aircraft swiftly and easily requires control cables of the utmost reliability, efficiency and endurance.

NEW COMMERCIAL JET-LINERS, as well as many military aircraft, are flying now with a unique remote control cable system made of special high-tensile wire wound around a stranded core with a heavy outer wire of stainless steel wound to a pitch of 10 per inch. This outer wire acts as a helix to engage hobbed wheels within the various system control boxes.

NATIONAL-STANDARD ENGINEERS worked closely with a control-cable system manufacturer to develop wire of just the proper alloy and rugged physical properties required to withstand extreme temperature and flight stress variations. National-Standard submitted wire samples to microstructural studies and physical tests to assist the customer in determining the conditions that would allow bending cable around pulleys without giving a permanent set to the cable. In addition, alloy steels with various coatings were tested to improve wear and galling resistance for various applications. The result was the development of a special stainless-steel wire that exceeded rigid specifications.

EXPERIENCED ENGINEERING HELP, of this kind, for jobs requiring high-quality wire to meet special or unique applications, is available to *you* from National-Standard. For any of the many thousands of applications where only special wire will solve the problem, let National-Standard engineers go to work for you. Write for additional information to National-Standard Company, Niles, Michigan.

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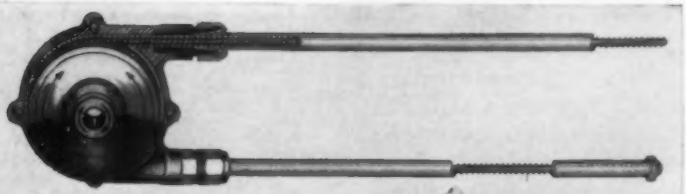
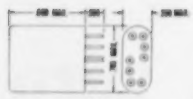
DIVISIONS: NATIONAL STANDARD, Niles, Mich.; tire wire, stainless, music spring and plated wires • **WORCESTER WIRE WORKS,** Worcester, Mass.; high and low carbon specialty wires • **WAGNER LITHO MACHINERY,** Secaucus, N. J.; metal decorating equipment • **ATHENIA STEEL,** Clifton, N. J.; flat, high-carbon spring steels • **REYNOLDS WIRE,** Dixon, Ill.; industrial wire cloth • **CROSS PERFORATED METALS,** Carbondale, Pa.; decorative, commercial, and industrial perforated metals.



FLEXIBLE CABLE engages accurately with specially hobbed wheels housed in control boxes. This combination requires special cable wire that will not take permanent set and will provide smooth, hard bearing surface for cable inside conduit.

NATIONAL-STANDARD engineers made intense microstructural and tensile studies of sample wire to find exact physical properties of the alloy to meet strict aircraft control specifications.



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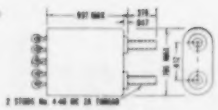
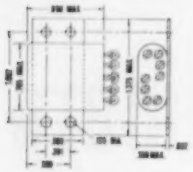
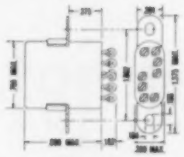


SC11DK
6, 12, 24, 36 Volts



SC11DB
6, 12, 24, 36 Volts

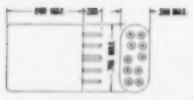


SC11DA
6, 12, 24, 36 Volts

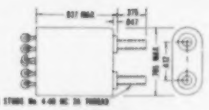
SC

2 TYPES • 4 MOUNTINGS • 4 VOLTAGES

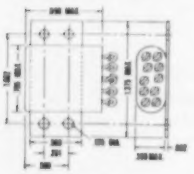
SL



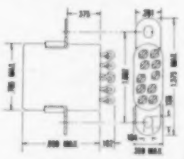
SL11D
6, 12, 24, 36 Volts



SL11DK
6, 12, 24, 36 Volts



SL11DB
6, 12, 24, 36 Volts



SL11DA
6, 12, 24, 36 Volts

Off the shelf delivery FROM YOUR P&B DISTRIBUTOR

32 STANDARD P&B CRYSTAL CASE RELAYS

Prototype or small-production-run quantities of P&B's micro-miniature relays are now available from your local electronic parts distributor. Choose from 2 types, 4 mountings, 4 coil voltages—32 models in all.

P&B's dual coil, permanent magnet, crystal case relays remain operative under 100g shock, 30g to 2000 cps vibration. Modern White Room production facilities assure highest possible reliability.

The SC conforms to standard dimensions and circuitry, and can replace ordinary relays of the same size.

The SL, a latching relay, utilizes the dual-coil, permanent magnet principle to provide a highly efficient, tenacious latch, assuring high contact pressure.

Order today from your local electronics parts distributor.

SC and SL SPECIFICATIONS:

Shock: 100g for 11 millisec.

Vibration: 30g from 55 to 2000 cps
.195" max. excursions from 10 to 55 cps

Ambient Temperature Range:
—65°C. to +125°C.

Contact Arrangement: dpdt

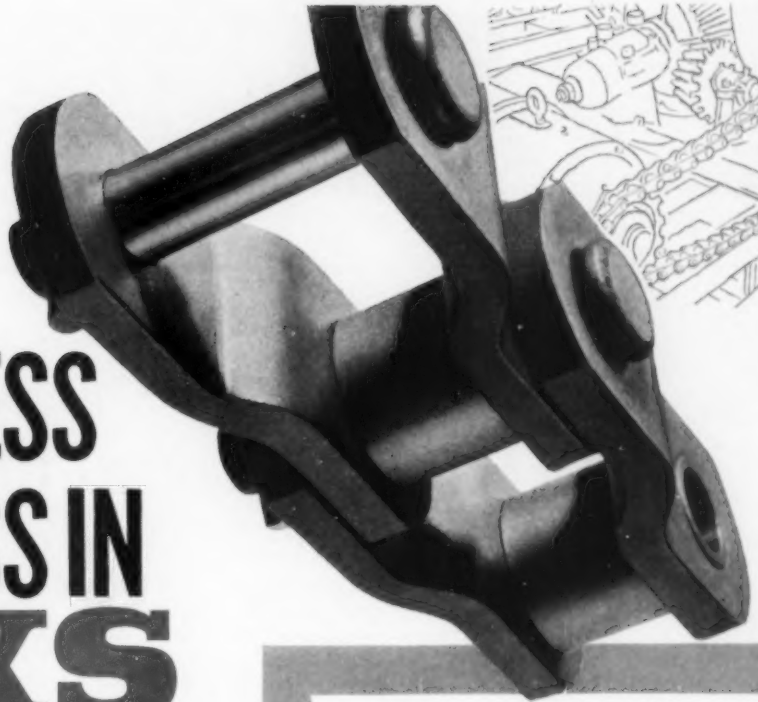
Contact Load: 2 amps at 30 vdc
1 amp at 115 vac, 60 cycle

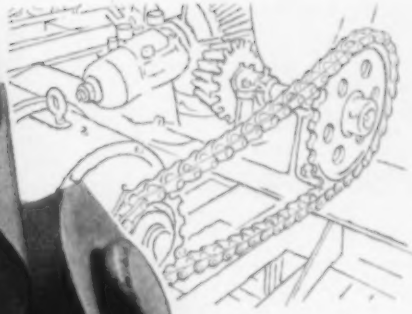
Sensitivity:
SL—230 milliwatts at 25°C. with 630 ohm coil
SC—260 milliwatts at 25°C. with 550 ohm coil

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

CIRCLE NO. 10 READER SERVICE CARD





FAR LESS STRESS IN LXS

THE CHAIN WITH NO "STRESS RAISERS"!
Link-Belt LXS brings long-term economy and efficiency to the most punishing drive and conveying jobs. With its "FULL-ROUND" design, LXS has no stress concentration points . . . none of the sharp corners which frequently shorten the life of many ordinary chains.

LXS is available with straight or offset sidebars. For details, contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.) Ask for our new, comprehensive Catalog 1050.

They're all of "FULL-ROUND" design

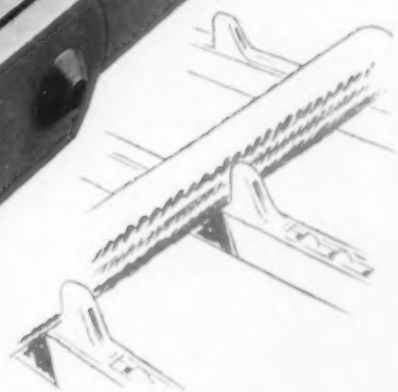
PINS BUSHINGS SIDEBARS

"FULL-ROUND" design eliminates traditional stress concentration points in Link-Belt LXS . . . provides maximum live bearing area between pins and bushings. Result: stress is distributed evenly.

Other LXS long-life features include controlled press fits plus use of selected steels and controlled hardening of all parts. All this contributes to greater uniformity, greater endurance.

LINK-BELT

CHAINS AND SPROCKETS



LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15.082

BEARING BRIEFINGS

One in a series of technical reports by Bower

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

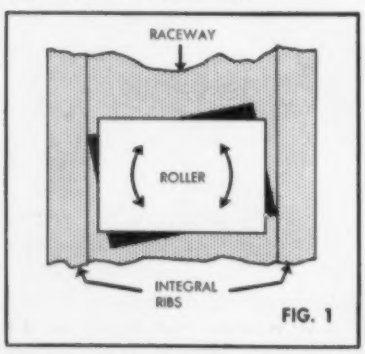
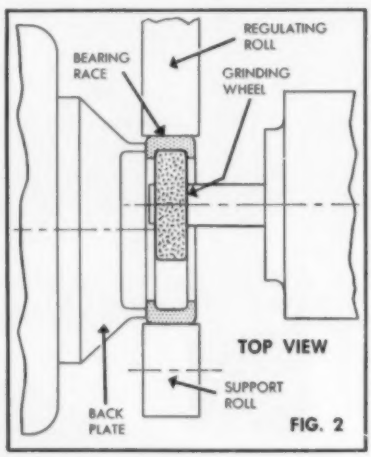
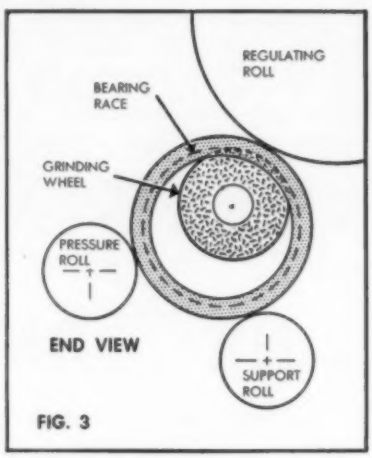


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.



★ ★ ★ ★

Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

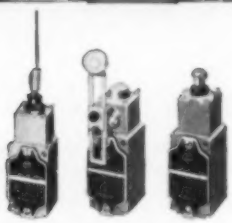
AUTOMATION BEGINS HERE

. . . Insist on Allen-Bradley accessories for continuous automatic production

In this broad line of Allen-Bradley accessories, each and every unit carries the traditional A-B trademark of *quality* that stands for trouble free operation. Rugged construction, and maintenance free, silver alloy contacts provide the reliability that is essential to the continuous operation of *your* automatic production machines.

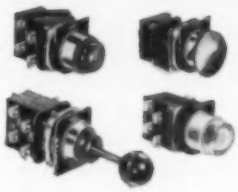
Profit from the experience of the leading machine tool builders . . . insist on Allen-Bradley *quality* motor control *all the way!*

Special push button panels can be assembled to your specifications

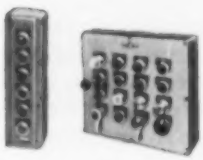


OILTIGHT LIMIT SWITCH
Bulletin 802T with sealed heads and bodies. Various operators.

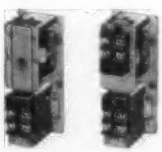
PRECISION LIMIT SWITCH
Bulletin 802 oiltight. Responds to very small operator travel.



OILTIGHT CONTROL UNITS
Bulletin 800T. Choice of push buttons, lights, and switches.

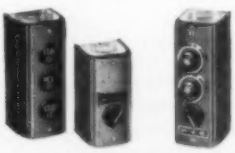


OILTIGHT CONTROL STATIONS
Bulletin 800T for up to 16 units in die cast aluminum enclosure.



PNEUMATIC TIMERS
Bulletin 849. Reliable and accurate. For on-delay or off-delay.

OILTIGHT PRESSURE CONTROL
Bulletin 836. For hydraulic systems with pressures to 5000 psi.



STANDARD DUTY PUSH BUTTONS
Bulletin 800. Up to three units, also pilot lights and switches.

FOOT SWITCH
Bulletin 805. In rugged die cast housing for toughest service.

ALLEN-BRADLEY
Member of NEMA

QUALITY MOTOR CONTROL

Allen-Bradley Co., 1329 S. First St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

PRESSURETROL*
PRESSURE CONTROLLERS

Here are new additions to Honeywell's broad line of pressure switches designed specifically for industrial use. Use them for reliable, economical control of liquid or gas pressure—alone as controllers, or with other instruments for limit alarm or signalling service.

1. MODELS P428A, B, C, D FOR CONTROL OF PRESSURES TO 3000 PSI

These *Pressuretrols* consist of a single-pole, single-throw mercury switch operated by a corrosion-resistant Bourdon tube. The case is designed to harmonize with other instruments, and is ideal for use in panels. It is compact, of drawn steel with a die-cast cover, and resists dust, weather and corrosion. The *Pressuretrol* can be surface or flush mounted on a panel or installed directly on a pipe. Pressure settings are made with two knobs conveniently located on the face of the unit.

SPECIFICATIONS

MODELS: P428A, standard case, spst, breaks circuit on pressure rise.
P428B, standard case, spst, breaks circuit on pressure fall.
P428C, explosion proof, spst, breaks circuit on pressure rise.
P428D, explosion proof, spst, breaks circuit on pressure fall.

Pressure Ranges	Maximum Pressures	Bourdon Tube
30— 300 psi	375	Bronze or stainless steel
50— 600 psi	750	Bronze or stainless steel
100—1000 psi	1200	Beryllium copper or stainless steel
200—2000 psi	2400	Beryllium copper or stainless steel
300—3000 psi	3500	Beryllium copper or stainless steel

2. MODELS P444A, B FOR INDEPENDENT HIGH AND LOW PRESSURE SETTINGS

Use these *Pressuretrols* in a wide variety of industrial applications that call for independent high and low pressure settings and switching action. A pressure-actuated, corrosion-resistant stainless steel diaphragm positions a mercury switch according to selected pressure settings. The mercury switch, scale plate and pressure setting indicators can be easily seen through a protective glass window in the cover. Pressure setting handwheels extend through slots in the cover. Adaptable for either surface or flush mounting.

SPECIFICATIONS

MODELS: P444A, standard case, spst, breaks circuit on pressure rise.
P444B, standard case, spst, completes circuit on pressure rise.

Range	Maximum Pressure
20" vac.—40 psi	75 psi
1—20 psi	50 psi
5—60 psi	80 psi
5—150 psi	200 psi

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

*Trademark

Honeywell

H HONEYWELL First in Control

THE ONES THAT WILL LAST (and last, and last!)? THOSE MADE FROM CONTINUOUS PROCESS

ZINC-COATED STEEL SHEETS

And just why will they last and last?

The people of the Galvanized Container Industry, always alert to make improvements to keep their products the best, can give you a multitude of reasons why. Chief among them: the continuous process insures a uniformly applied, corrosion-resistant zinc-coating. In fact, the zinc and steel are integrated to form a tight bond for every square inch, a durable coating which stands up to any rigorous stress of the fabrication process.

Continuous process zinc-coating will not chip or flake, no matter how much it is twisted, crimped or lock seamed. It can be worked to the very limits of the steel itself! Your budget benefits because there is no need for additional coating of any kind.

In continuous process zinc-coated steel, there is a stand-out—Weirkote. On your production lines and in your products, Weirkote will work for you all of the time. For detailed information on the many advantages of Weirkote zinc-coated steel, write today for a brochure. Weirton Steel Company, Dept. D-19, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

CIRCLE NO. 15 READER SERVICE CARD

Worker holds 2802 Hose Line of Teflon in curing mold. When tire carcass is inserted, hose line supplies steam pressure to inflate it against mold.

Aeroquip 2802 Hose of Teflon Solves Steam Line Problem

Major Tire Manufacturer Eliminates Constant Maintenance On Steam Curing Mold

A flexible steam line made of Aeroquip 2802 Hose of Teflon promises to solve a production bottleneck for one tire producer. Used on steam curing molds, it replaced rigid pipe and swivel joints that were a constant replacement problem due to steam leakage. Service life of 2802 Hose of Teflon is practically limitless in this application.

Aeroquip 2802 Hose of Teflon gives unequalled performance wherever extreme fluid temperatures are encountered (up to 500°F.) or where chemical stability, lubricity, flexing and long service life of the hose are critical factors. Use of detachable, reusable ***"super gem"*** Fittings permits quick hose line assembly and disassembly right in your plant, using ordinary bench tools.

Get full information on how Aeroquip 2802 Hose of Teflon can solve your fluid line maintenance problems. Call the Aeroquip Distributor listed in your Yellow Page Phone Book, or mail the coupon below for Bulletin IEB-40.

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Before: Pipe and swivel joints formerly used required constant maintenance due to leakage at swivel joints.

After: Aeroquip 2802 Hose of Teflon withstands constant flexing under high steam temperature without leaking.

"super gem" is an Aeroquip Trademark.
Teflon is DuPont's tradename for its tetrafluoroethylene resin.
*U.S. Patent Nos. 2,833,567 and 2,731,279.

PE-8

AEROQUIP CORPORATION, JACKSON, MICHIGAN

Please send me a copy of Bulletin IEB-40 on Aeroquip 2802 Hose of Teflon.

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DUPONT

ENGINEERING FACTS ABOUT

TEFLON®

FLUOROCARBON RESINS

Number M-3 of a series MECHANICAL DESIGN Hose of TEFLON

Pipe and swivel joint installations supplied steam heat and pressure to bag liners (not shown) for tire curing presses. Steam leakage and frequent maintenance were constant problems.

Replacement with hoses of TEFLON, as above, reduced steam leakage, resulting in lower maintenance costs. These less cumbersome connections also provide heat resistance, flex life, and reduced corrosion.

Unmatched stamina of hose lined with TFE resins brings production costs down

FOR maximum performance and durability plus reduced maintenance costs, hose liners of TEFLON TFE fluorocarbon resins offer this valuable combination of benefits:

Highly resistant to heat, TFE resins are rated for continuous service up to 500°F and withstand live steam and superheated water.

Hose of a TFE resin is exceptionally durable under continuous flexing, torque stress, vibration, and impulsing. This has been proven by strenuous military qualification tests and numerous industrial uses. With reinforcing, service pressures up to 6000 psi are being achieved.

TFE resins are completely inert to virtually all chemicals. This includes reagents such as nitric and hydrofluoric acids, and solvents including the non-flammable hydraulic fluids.

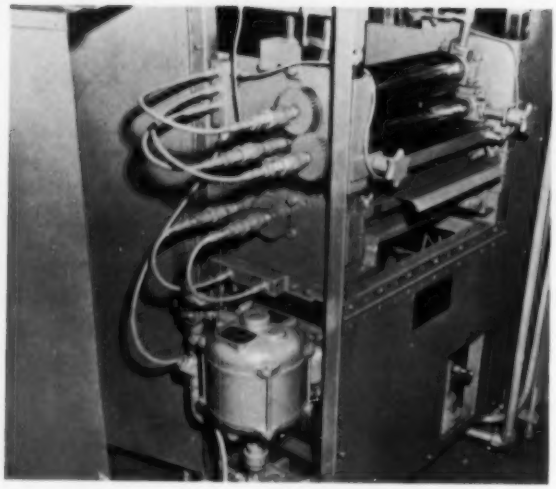
Liners of TFE resins provide a "waxy" inner surface which repels adhesion of sticky substances and scale, and are therefore readily cleaned and sterilized.

Today, using these valuable properties, a wide selection of industrial hose constructions with liners of TEFLON are available to meet your particular needs. In addition to the wire braided reinforcement and a variety of industrial couplings, there are elastomer coverings, fiber braids, air-duct styles, and convoluted liners of TEFLON offering greater flexibility.

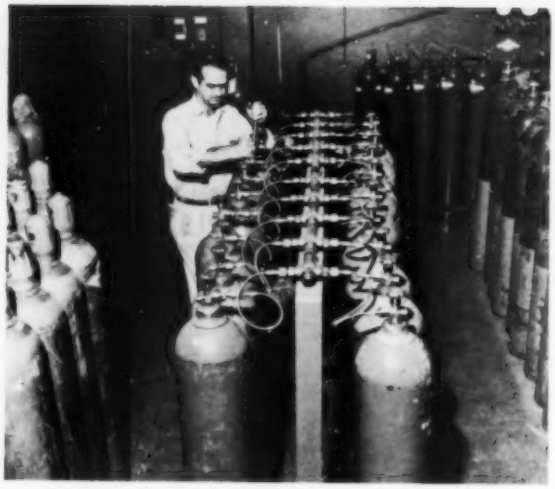
Examples of the cost cutting advantages made possible by hose of TFE resins are included on this and the following page. They may suggest ways that your machinery can profit from the remarkable properties of hose lined with TEFLON.

OVER

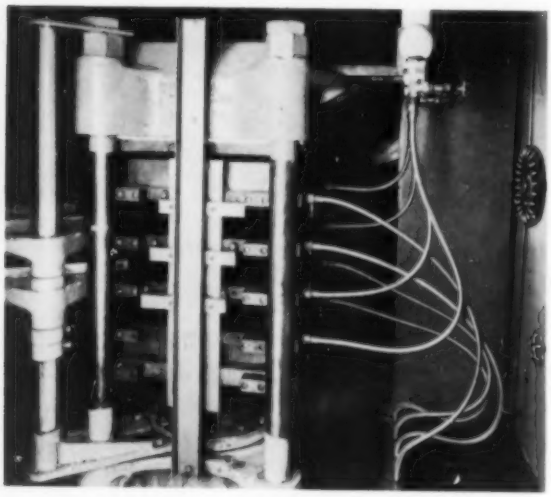
Hose of TFE resins takes live steam, corrosives, pressure, flexing without failure



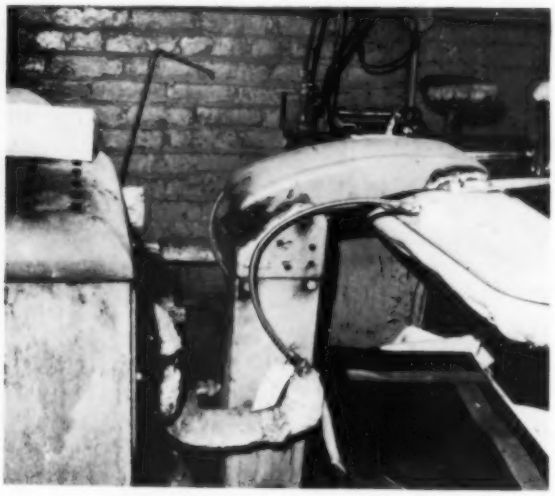
Hot Oil Service: Hose of TFE resin helped adapt this standard roller coater machine to high-temperature service. To suit customers' needs, the hose had to handle heat transfer oil at up to 400°F. Hose liner of TEFLON provided the necessary resistance to heat and solvents.



Cylinder Loading: At this plant, rubber hoses or metal pigtails lasted 3 months at best, loading helium, nitrous oxide, and carbon dioxide into cylinders. Hoses lined with TEFLON show no deterioration after 16 months. Reduced stiffening and frosting at the 0°F. loading temperature improved the weighing accuracy.



Reduced Scale Fouling: Hose is in alternate 350°F. steam and cold water service on this plastics platen press. Prior to the use of TEFLON, scale formation plugged hose in a matter of months. After 5 years, seven hoses lined with TFE resin were still unharmed and unplugged.



Longer Flex Life: Many cleaners and garment manufacturers are now using hose lined with TFE resins carrying steam to their presses. Above is one of 100 units at a location so equipped 16 months ago, and there have been no failures. Previously, hose life on some units was as low as two weeks.

FOR MORE INFORMATION...

about reliable hose installations, and the design properties of Du Pont TEFLON TFE-fluorocarbon resins that make possible this superior hose performance, consult your hose supplier or write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 3683, Du Pont Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

TEFLON *is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.*

TEFLON®

TFE-FLUOROCARBON RESINS

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

DEVELOPMENTS TO WATCH...

New polymers that can serve as semiconductors . . .

. . . are being made from activated carbons and carbon blacks, say recent reports from US and Australian researchers.

One system involves a modification of techniques for producing particulate materials that can serve as high-temperature gelling agents for lubricants (*PE*—Dec 9 '57, p 9). This system, now being explored at the Commonwealth Scientific and Industrial Research Organization (Melbourne), not only promises materials with pronounced semiconductor properties, but also absorbents for gases and liquids, and ion-exchange resins that can be regenerated electrically instead of chemically.

Another route to new semiconducting materials is nickel-doping. As Herbert Pohl and Jacques Laherrere of Princeton U reported to the U of Buffalo's special conference on carbon, carbonaceous polymers can now be produced in which the Hall-effect mobility (*PE*—May 4, p 38), therefore the electrical conductivity, increases as the temperature of processing and the percent of impurity increases. This way it is possible to tailor-make semiconductors with a considerable range of electrical properties. Both n-type and p-type materials can be produced; and potential uses range from thermoelectric generation to catalysis.

Temperature-sensitive paints get a new booster . . .

. . . as Space Technology Laboratories announces development of a series of color-change coatings for temperature control in missiles and satellites. Unlike many paints now available, these change color reversibly; should find many nonmilitary jobs.

The new coatings aim to take advantage of the fact that light colors reflect heat, dark colors absorb it. Thus a coating which got darker as the temperature dropped would help prevent satellite heat loss, while a change in the other direction would help keep it from getting too hot.

STL researchers say they've discovered at least 35 substances that will react this way, can produce either paints or layered plastics incorporating them.

Linear polyethylene will replace steel for 1960 Ford side-shields . . .

. . . and Ford engineers T H Risk and G M Buehrig have half a dozen good reasons for the change:

The polyethylene side shields will cost ⅓ less than painted shields; they offer styling advantages, permitting composite surfaces, part grained and part smooth; they have superior scuff resistance, and the finish color stays in because it is molded in.

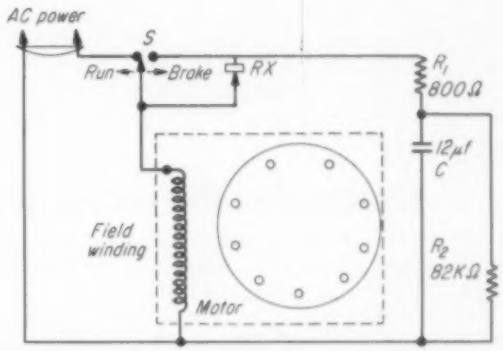
Biggest problem in the development was mold design; but Ford now believes that problem is solved, has ordered molds for quantity production.

A braking circuit that can serve . . .

. . . to control synchronous motors used as time-integrators and may also prove useful for systems in which position is preset by a controlled period of motor energization has been developed at Naval Research Lab.

The system was designed to overcome the time lag that normally occurs because such motors have a tendency to "coast" when its power is turned off.

In the original design (see diagram) the motor is a standard 3-watt unit of the type used in electric clocks. The braking circuit is controlled by a snap-action switch capable of completing its action in an interval "on the order of one-half cycle of a line current." A 12-mf capacitor is used and resistors are rated at 800 and 82,000 ohms. With these elements, storage rate in the capacitor is about 0.17 w/sec.



Synchronous motor is controlled by braking circuit that includes a snap-action switch S, capacitor C, diode RX, and current-limiting resistor R_1.

While the motor is running, explains NRL, the capacitor is charged to peak line voltage through the diode and current-limiting resistor. Then, when the switch is thrown into brake position, it discharges the capacitor through the field winding, stopping the armature rapidly and effectively by arresting and holding the magnetic field.

DEVELOPMENTS TO WATCH...

New standard for atomic weight that will affect calculations . . .

. . . on everything from storage-battery efficiency (*PE—May 25, p 46*) to lube-oil formulation now seems close to adoption. The present standard, long used and liked by chemists, takes natural oxygen as the reference point, giving it the whole-number value 16. But, as the physicists have been pointing out, natural oxygen is actually a mixture of isotopes, differing in nuclear mass, and so represents only a rough average. They've been pushing for adoption of a specific isotope—oxygen 16 as the standard. The solution, on which it looks now as though agreement will be reached, involves a new entry: carbon 12. This would be used by both chemists and physicists, with oxygen being discarded.

The change, if it comes, will not be a great one, but it will systematically lower all present atomic weight values by 0.0042%.

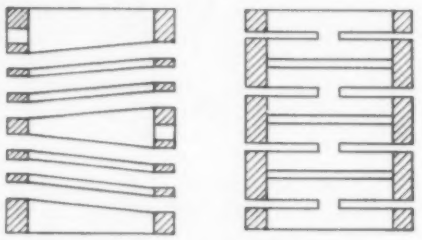
Late this month, in Munich, the Commission on Atomic Weights of the International Union of Pure Applied Chemistry will take up the question, and provisional approval seems virtually assured—subject to similar approval by the International Union of Pure and Applied Physics. This organization will meet next year in Canada. If it goes along with the idea, final approval should come in 1961.

Dr Edward Wichers of our own National Bureau of Standards is chairman of the IUPAC commission, and will represent us at the meetings.

Torsion-free cylindrical measuring springs . . .

. . . that "have no hysteresis and therefore show exactly the same calibration after loading as before" are claimed by Dr Werner Roehrs KG, Sonthofen, West Germany. They're machined from tubular materials instead of by winding, to eliminate the friction of the end surfaces.

The two types now being produced are a "hard" type (left) with a steep output curve; and a "soft" type (right), with a flat output curve. To make the hard type, grooves are cut at right-angles to the tube axis, staggered at 90° angles to each other. For the soft springs, the tube is milled so that oppositely directed screw passages are made.



Load-carrying capacity and spring rate are determined by selection of profile and length of spring elements in relations to over-all dimensions.

Laminated aluminum foil is stronger and lighter than solid sheet . . .

. . . Wright Air Development Center engineers report, and the material seems more resistant to fatigue failure, too. Using 1100-H18 aluminum foil, 0.0035 in. thick, oriented in a variety of ways and bonded with epoxy resins, they have built up sheet materials 0.052 in. thick that exhibit ultimate tensile strengths to 27,000 psi and elastic moduli in the 9.5 x 10^6 range. The material is not yet ready for commercial production. Direction of orientation, bonding resin, and bonding treatment are all critical factors about which much more must be learned. But WADC has high hopes for the material.

Open-type relief valves do not constitute a hazard . . .

. . . in handling most vapors, even when the vapors themselves are flammable, W. C. Bluhm of Shell Oil Co told a recent API meeting.

There are cases where open valves cannot be used. However, he says, these situations are in the minority.

Likewise, he believes, special dropout systems for fuel-oil-process heaters are largely unnecessary and ineffective. "It has been our experience with furnace-tube failures that, in the majority of cases, they are detected while leakage is still minor, and orderly procedures can be followed, such as depressurizing the unit, cutting fires, shutting off or diverting feed, admitting purging steam to the firebox, and allowing the furnace to cool until liquid can be safely removed." With pressure off the heater and purging steam in the firebox, liquid which does drain into the furnace during the cooling period should not result in a hazard.

Over-all import of his remarks: Equipment designers and installers have, if anything, become too cautious, are designing-in safeguards that defeat their own ends by being too complex or coming into play too late. —ARG

Japanese computer in Paris . . .
has arithmetic and control circuits made up of parametrons. Computer elements are essentially oscillating circuits in which one of the reactances is varied with a frequency about twice that of resonant frequency. Result: excitation frequency is available in two discrete phases 180° apart. Also, the phases can represent the binary digits, 0 and 1. Computer speed, made by Hitachi, is 4 millisec (including access) for addition, subtraction; 8 millisec for multiplication; 35 millisec for division.

Sweden, Japan Highlight Paris Computer Show

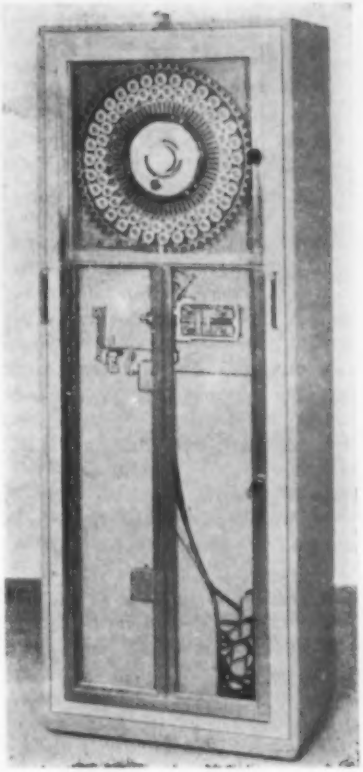
PARIS—Computer manufacturers from 8 countries displayed their newest memory devices in the Grand Palais here for 2000 delegates attending the UNESCO conference. While US companies and their overseas subsidiaries accounted for half the exhibits, France, Germany and England were well represented. The USSR, fearing damage to its delicate gear in transit, didn't attend.

Attracting considerable attention was the Gamma 60 of Compagnie des Machines Bull, reportedly the first production computer capable of processing several problems simultaneously, thanks to a system of parallel unit operation. While the print-out unit, for instance, is tabulating results of one problem, other units are working on additional problems. When a unit has finished its part of the problem, it signals to the central storage unit that it is ready to start on the next. A Japanese computer with parametron-circuit elements (see photo above) was another highlight, along with a Swedish tape unit.

Another show, Electrama, staged by French electrical-equipment manufacturers in company with the National Railway Administration, the French Atomic Energy Administration and the French Dept of Defense, featured a "top to bottom" exhibition of electrical equipment, but showed nothing not previously reported. Significance of the show was the visible proof that the French industry's annual output ($1.83 billion) is 5 times prewar. ■

California Firm Hires Summer Engineers

SACRAMENTO—More than 50% of the applicants for summer jobs with Aerojet General Corp's plants here are college students majoring in engineering and science. Some 363 students were hired by the firm to give such students a practical view of industry in action. ■



Carousel design . . .
features this Swedish computer's magnetic tape memory unit. It has a 17-in.-dia wheel with 64 independent tape wheels, each holding 28 ft of tape with a capacity of 8192 words of 40 bits each. Access time for each block of the 5 million digits that can be stored is 1.9 sec because instead of running through a lengthy piece of tape, the carousel-like wheel spins the appropriate reel to the reading head, and then runs only 28 ft of tape past it at 200-in.-per-sec speed. An on-off servo system gives the high-speed, start-stop operational flow required for the carousel.

Soviet Engineers Swap Shop Talk with PE Editors

NEW YORK—What does the USSR mean by serial production? To what extent is transistor production mechanized in the Soviet Union?

These are a sampling of questions PRODUCT ENGINEERING editors threw at six Soviet engineers (and one translator) who are in New York for their nation's exhibit of Science, Technology and Culture at the Coliseum (*PE—July* 13, *p* 21; *July* 20, p 21). The round-table discussion between USSR engineers and US editors took place several blocks away, in the McGraw-Hill building. A full report of the proceedings will appear in the very near future.

In brief, serial production—a term used by Khrushchev to describe the present status of Soviet ICBM missile output—means production that lies between custom jobs and our notion

of mass or assembly line production. In Soviet parlance, production is described by three terms: large serial—roughly comparable to our assembly lines—serial and small serial.

About half of Soviet transistor production is done by machine and about half by hand.

The Soviet visitors also turned tables and put questions to PE editors. Their queries reflected intense interest in programmed machine tools and automatic production lines. They wanted to know the prices of basic machines and electronic attachments; how common are automatic lines in the US for metal cutting lathes; and how common here is digital control of lathes.

Many of their questions were very specific. They asked about trends toward electromachining of metals and the maximum power developed in ultrasonic machine tools here. In machining profiles such as turbine blades, they wanted to know if US engineers had developed drives for stepless changing of angular velocity during one revolution. And on the question of V-belts, they were anxious to know whether the US has stepless drives with side v-belts and what power and revolution ranges were designed into such equipment.

They were exceedingly anxious to obtain catalogs from manufacturers of machine tools, hydraulic, pneumatic and electrical equipment. ■

Jet of Water Streamlines Production of Copper-lead Bearing Powder

DETROIT—A water-jet atomizing process that promises to produce twice as much copper-lead bearing powder as conventional methods is being used by Federal-Mogul-Bower Bearings Inc. Molten alloys of various analyses of copper, lead, tin, zinc, and other metals are atomized to produce the powder.

The desired alloy is melted and poured through a small orifice into an atmosphere-controlled chamber where it is hit by a high-pressure jet of water. Jet pressure is controlled to produce microscopic particles which are spherical in shape and, when sectioned, show uniform structure and distribution of alloy. This powder is then dried and passed through a series of screens. No particle is used which will not pass through a screen mesh with 10,000 holes/sq in., and about 50% of the powder used will pass through a minus 325 mesh screen (105,525 holes per square inch).

Nitrogen gas, used as the atmosphere in the atomizing chamber, reduces oxidation to lowest level.

In use, the copper-lead powder is bonded onto a steel backing in an electric sintering furnace. The resulting coil of bimetal strip is then cold-formed into bearings and bushings on multiple stage dies.

The bimetal strip may be cold-flanged in presses without crackling the copper-lead layer and without rupturing its bond to the steel back. Uniform lead distribution achieved by use of the powdered alloy eliminates uninterrupted lead areas and the planes of weakness found in cast linings. This is not only an aid to flanging but retards lubricant corrosion by closing the paths of attack .

High density of the powder, resulting from using particles of varying size, makes it possible to spread it onto the steel backing with a variation in thickness of less than 0.001 in.—permitting a minimum allowance for machining, which in most instances can be reduced to a broach cut only.

These bearing powders have application not only in the bearing industry but can be custom-atomized for: high temperature brazing use in jet engine and rocket component parts; special corrosion-resistant filters; new slip-casting techniques to produce intricate shapes without costly machine operations; and others. ■

British May Replace Zeta Machine

NEW YORK—Britain's zeta machine, designed to harness the power of the H-bomb, may be scrapped. According to the nation's Atomic Energy Authority, designs are being prepared for a new system.

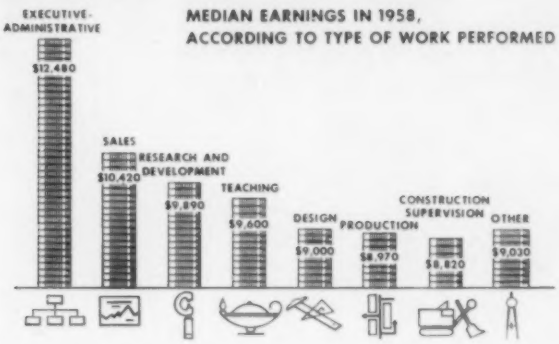
Some 18 months ago, a British scientific team announced that it had apparently controlled thermonuclear fusion (reaction of the H-bomb) in achieving temperatures of 5 million degrees, but only for very brief periods.

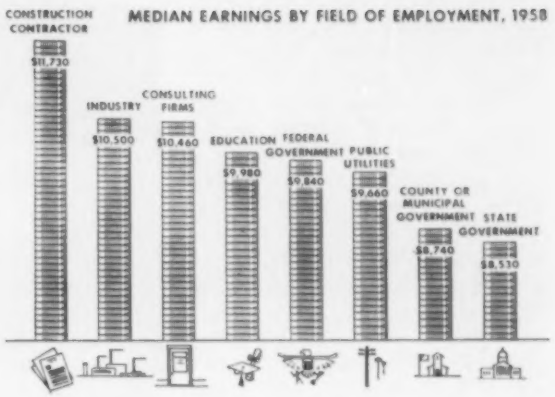
It has been the general concensus that claims made by the British scientists a year and a half ago were over-optimistic. ■

New Vibration-test System Developed for Bomarc

One of the world's two largest electronically driven vibration systems—a 200-kw setup capable of exerting a vibratory force of 25,000 lb through frequency test ranges from 5 to 2000 cps—has been developed by Boeing for its pilotless-aircraft environmental laboratory. The vibration tester will encompass Bomarc missile systems and components weighing up to half a ton. Its exciter is 6 ft high; mounted on a 200,000-lb concrete slab; side-insulated with 2 in. of cork and with tie-down rails for horizontal shaking. Pre-amp and amplifier are housed in a walk-in cabinet 18 ft long, 5 ft deep, 8 ft high. Shaker will vibrates a 1000-lb missile package in complex wave tests.

Salary Survey Shows Professional Engineers Still in Lead





WASHINGTON—In engineering, too, it pays to have the proper papers. The 4th biennial "Professional Engineers' Income and Salary Survey" announced that the median 1958 income for professional engineers was $10,000 . . . by contrast, median for all engineers was $8750 (*PE—Jan 5, p 26*). Another highlight from the NSPE report shows chemical engineers again topping all the professionals—with a median of $11,170.

In general, says the report, earnings are higher at all levels but gains are smaller than recorded in the '52, '54 and '56 surveys. Median is up 5% in the '58 survey, compared with 9% in '54 and 12% in '56.

Upper quartile earnings for '58 show only a 3% increase; in 1956, the increase was 10%. Upper decile incomes dropped 1% from the 9% increase reported in 1956. However, only 10% of the 19,240 reporting professional engineers listed incomes below $7040. At least 75% reported incomes of $8250, and the upper 10% earned at least $19,680.

Contrasted with chemical engineers, civil engineers were at the bottom—despite a jump from $8750 in 1956 to $9620. Electrical and mechanical engineers had medians of $10,270 and $10,250, respectively.

One feature of the 1958 report is a detailed analysis of salary trends recorded in the four surveys conducted since '52. Major trends reported include:

- All segments of the profession enjoyed further income gains, but engineers connected with the business sector experienced smaller relative gains than professional engineers in other types of employment.
- While the younger engineers continued to register salary increases, their gains were in line with those of the more experienced engineers, and not considerably higher as in the past.
- There appears to be a continuing trend—first apparent in 1956—toward a gradual lessening of certain types of income differentials. In particular, regional salary differentials seem to be decreasing, and there also seems to be a tendency for the various fields of employment to pay similar salaries for comparable work.
- In particular, the gap among earnings in industry, educational institutions, and the government was narrower in 1958 than ever before. ■

High Subcontracting Costs Force Electric Car Maker Overseas

SAN DIEGO—Beset by production problems and high vendor costs, Stinson Aircraft Tool & Engineering Co is negotiating with German and Japanese manufacturers to produce parts for its all-electric car. Stinson has 110 orders for its Charles Townabout model, retailing for about $2800 in the US.

Deane L. Van Noy, Stinson president, charged that US suppliers of hardware such as electrical equipment, wheels, brakes, and instruments are "trying to amortize their tooling costs at our expense." He said prices for these components now far exceed the original quotes, and that even with anticipated customs duties, foreign parts would be considerably less expensive.

Van Noy added that it cost Stinson $3972 to hand-produce the first three models. "We expected to take a little loss on them," he explained, "but this is too much. Even at the rate of 500 cars a year, the cost would only be a little less."

He said Japanese and German firms have shown interest in producing the Townabout's chassis, frame and running gear, and added he is considering producing the entire car overseas.

Gordon Plastics of San Diego, makers of the fiberglass plastic body for the Townabout, reported that even if the rest of the car is produced in Germany and Japan, Gordon will continue to make the shell, which can be added to the otherwise completed body. Gordon reported that bodies on completed models are satisfactory, following earlier production snags.

Production schedules and planned output of 160 cars monthly by 1959 have been abandoned. ■

A-specialist Shortage Cues Paris Conclave

PARIS—The shortage of atomic specialists is worldwide and runs the gamut from top-ranking university professors in some countries to reactor maintenance personnel in others but instituting "crash" programs of education is not the answer.

This was the global picture drawn

by some 60 scientists from 30 countries who met recently at the French Nuclear Research Center near here to discuss mutual problems. At the seminar, sponsored jointly by UNESCO and the International Atomic Energy Agency, discussion centered on the whys and wherefores of training nuclear specialists. The general consensus was that study of nuclear sciences should start at the secondary-school level, but only after a solid grounding in classic physics and chemistry.

Explaining the feeling against "crash" programs, one participant said "the need for ingenuity, initiative, intelligence and imagination" makes a broad general education essential to the nuclear specialist, who mustn't be isolated from the outside world.

Scientists at the seminar also agreed that advanced nuclear subjects must be taught where large experimental reactors and particle accelerators are available. This requirement, many thought, rules out universities, which generally cannot afford the expensive research equipment necessary. Nuclear research centers were tagged as the logical places for training.

But opinion varied widely on how to integrate university and research-center training programs. Some felt the only way is to decentralize training and set up programs in nuclear sciences and technology in a large number of universities, adding that good researchers are not necessarily good teachers. Others plumped for training at a few well-equipped centers where instruction in highly specialized techniques could be given by specialists. A suggested compromise was to have university professors teach in conjunction with researchers at research centers. ■

China Adopts Metric System

TOKYO—Red China has adopted the international metric system as its official basic system of weights and measures, according to a Peking radio report received here. It said that only in special cases would the British system of weights and measures be used, but nautical miles for navigational measurement will continue to be used. The Chinese government explained it is allowing for a gradual changeover, particularly in the remote provinces. ■

Plastic Foams developed for Impact Cushioning

Crushable plastic foams developed by Atlantic Research Corp, Washington, DC, for protection of air-dropped supplies. When the two-liquid formula is mixed, it rapidly foams and sets. Formula variations will produce uniform foam structures, some fine and some coarse, with a wide range of fragilities and densities. (For information on crushable structural materials see *PE—Aug 10, p 12.*)

Some Machine-tool Standards Approved for "Building Block" Concept

DEARBORN, MICH—Four years of negotiation and study of the "building block" (unitized-design) concept by suppliers and users of production machine tools has turned up a limited series of standards, according to a spokesman for the group, Henry C Daum, manager of Ford Motor Co's Machining Process Dept.

Scope of the standards agreed upon covers the mounting and attaching surfaces of certain components and units for a production machine capable of drilling, boring, reaming, tapping and related operations—its operations can be performed automatically or semi-automatically, depending on controls specified by the procuring activity.

Purpose of the program is to reduce obsolescence cost of expensive special-purpose equipment. The unitized-design approach permits replacement of one or more sections of a production line with other standard sections. The basic line can thus be adapted to production of newly designed parts.

Basic components and units affected by these standards which form the nucleus of production machine tools are; main base, wing base, way-type feed unit, quill-type feed unit, horizontal angular adapter, angular column, dial-type wing-base adapter, and vertical column. The five subclassifications for single-station machines are: 1-, 2-, 3-, 4-way and more than 4-way; for multiple station machines: transfer, dial, trunnion, center column, and shuttle.

HERE ARE REQUIREMENTS

According to a standards chart issued from Dearborn, requirements call for incorporating the standardization of this specification for the mounting and attaching surfaces, bolt pattern, bolt sizes, location method and the uniform work height for the 8 components and units which, in varying combinations, form nucleus of a production machine tool. A work-loading height of 42 in. shall be maintained on all single-station and multiple-station machines excepting trunnion types.

"The 'building block' or 'unitized automation' should encourage incorporation of technological advancements and product design changes which

benefit the buying public because the flexibility of equipment will make the changes less costly," Daum explained.

"The concept also appears to be the answer to extending the automatic production line into new areas of industrial use: purchase of the new equipment will be more economically practical for smaller companies." ■

COMING EVENTS

AUGUST

4-5 . . . . American Astronautical Society, 2nd Annual Western Regional Meeting, Ambassador Hotel, Los Angeles.

4-6 . . . . Society of Photographic Instrumentation Engineers, Annual Convention and Exhiborama, Ambassador Hotel, Los Angeles, Calif.

18-21 . . . . Western Electronic Show and Convention, Cow Palace, San Francisco, Calif.

23-25 . . . . American Society for Metals, Eastern New York Conference on Fracture of Engineering Materials, Rensselaer Polytechnic Institute, Troy, N. Y.

SEPTEMBER

10-11 . . . . Society of the Plastics Industry, Midwest Section Conference, French Lick Sheraton Hotel, French Lick, Ind.

20-25 . . . . Instrument Society of America, 14th Annual Conference and Exhibit, Chicago Amphitheater and downtown hotels, Chicago, Ill.

21-22 . . . . Steel Founders' Society of America, 57th Fall Meeting, The Homestead, Hot Springs, Va.

22-24 . . . . Armour Research Foundation and NUCLEONICS magazine, Industrial Nuclear Technology Conference, Morrison Hotel, Chicago, Ill.

23-25 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, 4th Annual Special Technical Conference on Non-linear Magnetics and Magnetic Amplifiers, Shoreham Hotel, Washington, D. C.

23-25 . . . . Office Equipment Manufacturers Institute, Business Equipment Exposition, National Guard Armory, Washington, D. C.

28-Oct 1 . . . . American Welding Society, Fall Meeting, Sheraton-Cadillac Hotel, Detroit, Mich.

OCTOBER

1-2 . . . . Society of the Plastics Industry, 15th New England Section Conference, Wentworth-by-the-Sea, Portsmouth, N. H.

Army Develops Assists for Missile and Rifle Men

FORT BELVOIR, VA—Three developments reported out of Army Engineer Research and Development Laboratories here show promise of streamlining operations for the Army's foot soldiers as well as its missilemen.

Under test is an airborne ditch-digger that can dig a trench 4 ft deep and 24 in. wide at a rate of 12 fpm. The rubber-tired hydraulically retractable ditcher can achieve road speeds up to 35 mph. Designed to support earthwork operations on construction projects, it can dig ditches to a depth of 6 ft, can excavate a foxhole in 2 min. or a machine gun nest in 5 to 10 min. It is expected that the ditcher will give protection for front-line and rear-echelon troops against atomic blast and fallout.

The laboratories have also developed vacuum-blower cleaners to help clean complicated electronic devices used in the Army's Nike-Ajax, Corporal and Sergeant missiles. Compact and lightweight, the cleaners can either produce a high vacuum or develop a jet stream for blowing a jet of air, and be operable on the type of power available at missile sites.

The cleaners are equipped with a ¾-hp motor which operates off 115-v, 60 or 400-cycle, single-phase current. In test the 400-cycle pulled 28 in. of water through a ⅛-in.-dia orifice, pulled 21 in. of water through an orifice of ¼ in. dia, and 10 in. of water through an orifice of 1 in. dia. The cleaner has sealed-in lubrication, is equipped with brush and nozzle attachments rendered nonconductive to prevent shock when used around electronic gear.

A shielded inert-gas arc welder that differs from conventional dc welders by furnishing both ac and dc welding current for metal arc or tungsten inert gas welding has been developed for the Redstone missile program. This unit also provides dc for metal inert-gas welding and consumable electrode process welding by attachment of any of several commercially available wire feeders and consumable wire guns—this includes push or pull, and water or aircooled guns up to 300 amp. ■

Japan Opens Door To Foreign Technology

TOKYO—The Japanese government has broken down one of the barriers it erected to limit foreign investments and licensing agreements between Japanese and foreign companies.

Heretofore, the Ministry of Finance and the Ministry of International Trade and Industry (MITI) insisted on including a guarantee of exchange remittance on all foreign investment and license agreements. It assured the foreigner he could convert yen earned here into his national currency.

But the guarantee rigorously limited the number of agreements that government agencies would approve. Foreign exchange holdings of Japan have been scarce in recent years. (These are the holdings of foreign currencies for settling trade balances.) Only the most urgent agreements were passed in order to limit a potential drain on foreign exchange.

Now MITI and Finance Ministry say they will approve even licensing and investment agreements that do not include guarantees of remittances. In other words, if companies are willing to accept certain limitations on their currency conversion rights, the Japanese government will now let them. At present approximately 200 foreign license and investment applications are pending here. The government apparently expects foreign companies to continue interest in investing in Japan, and foresee an upsurge in foreign investment. ■

Europe Edges Toward Increased Soviet Trade

WASHINGTON—US officials believe an increase in British-Soviet trade may be forthcoming. There is growing talk in London of the government's providing 5-year guarantees on credits that British firms extend to the Soviets for purchases of heavy machinery.

Manufacturers in other European countries are likewise putting pressure on their governments for aid to finance trade with Russia. If such pressures are successful, US businessmen will undoubtedly press for eliminating restrictions against US-Soviet trade. ■

Reader To Editor...

Vive Standardization

To the Editor:

I want to underline the article, "US shift to metric system" (May 18, p 11). You in America already use the metric system in the electrical field—the watt, joule, volt, ampere belong to the M K S A system. All the world agrees about these units, why not agree about other units of measurement as well?

—Jacques Faisandier
Technical Manager
Societe D'Applications Des Machines Motrices
Boulogne-Billancourt, France

Optimistic Artist

To the Editor:

Have just received the July 6 issue. On page 5, an article repeatedly mentioned 50 states, 50 starts and 50 products pictured on the cover. We believe your artist has miscounted because after counting and recounting the stars and products, we arrive at 51 of each every time.

—Thomas Vlattas
Willgoos Laboratory
Pratt & Whitney Aircraft
East Hartford, Conn

• Our artist was either subconsciously in favor of cleavage of New York City (his home town) from the State, or felt that a 51-star pattern would work out much more aesthetically than a 50-star in the flag.—Ed.

Book on Fasteners

To the Editor:

Your article "Roundup of Assembly Methods" (p 91) in the June 8 issue devotes considerable attention to fasteners. Your omission, therefore, of my book *Fasteners Handbook* in your bibliography of the article puzzles me. There are so few books published on the subject of fasteners, you surely must be aware of it.

—Julius Soled, PE
Asbury Park, NJ

New Time System

To the Editor:

The letter by D. R. Bross of Canoga Park, Calif, regarding a more convenient time system (p 42 of your June 22 issue) has prompted me to propose a modernized clock and time system:

The present 24-hour day would be divided into 10 hours, and the new hours would each be equal to the former period of 2 hours and 24 minutes. Each of these hours would be divided into tenths, which might be called Decis, and each of these Decis in turn divided into 10 parts or minutes, each Deci equalling 14.4 minutes of the present system, the new hour thus consisting of 100 minutes. Each of these minutes would be divided into 100 seconds, the new seconds being slightly smaller than at present, and the new day would have 100,000 seconds instead of the present 86,400.

Advantages of the proposed time and clock system are immediately apparent. An interval between any two times can be immediately obtained by direct subtraction. The system can be extended and include time periods between days. For example, Apr 23 is the 113th day of the year, and Sep 1 is the 244th such day. Under our present system, a period between 8 pm, Apr 23 and 10 am, Sep 1 of any year would, in the new system, be represented by the figures 113.712 and 244.420, and the interval between them would, by direct subtraction, be 130.708 days. This type of calculation should be very valuable in astronomical and space calculations.

—C Lauren Maltby
Sierra Madre, Calif

Gear Puzzle

To the Editor:

The author states in "Workable Approach to Gear Tolerance" (May 25, p 52) that gears specified to a measurement over wires are more economical to produce and inspect than gears specified to center distance measurement. This statement seems misleading because precision gears must also meet the specifications for total and tooth-to-tooth composite error, which cannot be checked by micrometer and wires.

Another point that puzzles me is that, referring to the author's table which gives the minimum and maximum backlash values for 20° and 14½° pressure angle gears, the 1.0506 measurement over wires must apply only to a 20° gear. However, since the corresponding dimensions for a 14½° gear is 1.0516, a 14½° gear cut according to the author's table would be 0.0004 in thinner than standard, and backlash between a pair would be 0.0008 greater than that listed in the author's table for the 14½° gear.

A third point that I take issue with is that the author does not recommend specifying a standard shaft center distance. From a user's standpoint, it is much safer to do this because it is based on the number of teeth and pitch, and can be easily calculated without reference to tables, etc. Specifying a standard CD also makes it possible to change from Precision I gears to Precision II gears with minimum difficulty—the housing drawing can be revised by simply reducing the tolerance on the CD; original jigs or other tooling can be used with minimum change.

—Carl A Johnson
West Palm Beach, Fla

• Author W A Wiegand tells us that his inspection procedure is to check all gears for run out, tooth-to-tooth errors, etc, on a center distance checker. He does not use this equipment, however, to check the center distance itself because this would mean a time-consuming readjustment for each different size gear. This latter information is obtained by means of measurements over wires.

Minimum and maximum backlash values were obtained from the approximate equation, $B = 2\ (\Delta CD)\ \tan \alpha$, where α is the pressure angle. These values were not obtained from the measurement over wires. This latter figure pertains only to 20° gears—as you rightly point out.

It would be difficult to give one standard CD for all classes of gears. For example, Wiegand's group recommends a 1.0014 + 0.0004 — 0.0000 dimension for a certain set of Precision I gears (nominal CD is 1.0000), and 1.0008 + 0.0003 — 0.0000 dimension for equivalent Precision II gears. In other words, the CD for Precision I has not only a larger tolerance but also has a larger minimum dimension.—Ed.

What Manner of Men?

To the Editor:

After reading "Horizons" (June 15, p 21), I would suggest that you further contemplate the various possible interpretations you might make of Dr Wiener's remarks. Or preferably, you might discuss the interpretation with Dr Wiener. I do not know him but he might very well speak as follows: "Initial evidences are that the industrial machine, a midget beside the giant brains, is already beginning to destroy its creators." He might also point out that the relationship of man to these products of man is through organizations, not through an individual; and as you may know, an organization frequently shows no or few human-like qualities and no soul, no heart, at times no moral integrity and frequently no sense of guilt for obvious sins.

Man may destroy systematically each honest God-given value that makes him man—one by one.—Millard D Zeisberg
Newark, Del

Shakespeare and Dr Wiener

To the Editor:

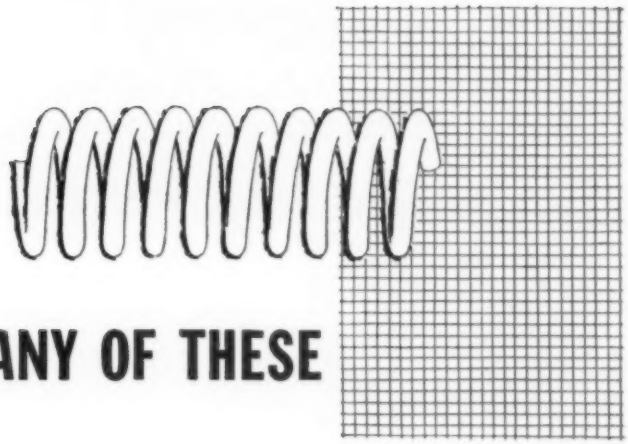
You do Dr Wiener a great disservice in condemning his statements concerning the thinking ability of a machine (June 15, p 21). At the present rate of progress, this may well be possible in the foreseeable future. Too many people feel that only a proteinic living cell of the type they can see wiggling under a microscope is a living creature. No one knows now just what constitutes life or thought. Life is intimately tied up with (and dissolved by) electricity. Is electricity life?

Shakespeare had it correctly when he had Hamlet say, "There are more things in Heaven and earth, Horatio, than are dreamt of in your philosophy."

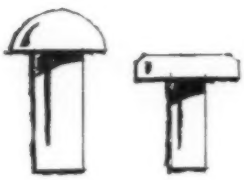
How now, Horatio, admit that Norbert Wiener may well be right.

—Lloyd A Buchalter
Ridgefield, Conn

• Shakespeare also said, "Let the end try the man."—Ed.



IF YOU MAKE ANY OF THESE



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Now available on all Parker-Hannifin

STRAIGHT THREADS FOR LEAK-PROOF

Industry's new standard as published in J. I. C. Recommendations (April, 1959) and S. A. E. Standards (1959 Handbook)

Why accept less?

Parker-Hannifin now offers a new standard *at no extra charge*—high-pressure hydraulic components with straight thread port connections* for O-ring type fittings. This new standard—assuring a leak-proof and drip-free seal—is the most logical engineering approach to the problem of hydraulic circuit connections. The Joint Industry Conference Recommendations now state:

"Fittings that incorporate separate synthetic or metal-to-metal seals, or seals that seal with pressure *should* be equipped with Unified National Fine (UNF) straight thread port connections."

And the Society of Automotive Engineers' 1959 Handbook states:

"The S.A.E. straight thread 'O'-ring boss is the preferred port for use in hydraulic devices."

Both support this new standard—and the U. S. Navy Bureau of Ships in MS16142 (SHIPS) has adopted the S.A.E. Straight Thread Boss Design as their straight thread standard for use in hydraulic and air systems in Naval ships. Such extensive support is understandable. The Parker-Hannifin straight thread port connections combine a built-in pressure sealing device with a rigid mechanical connection. This contrasts with the loose connection of a "backed-off" pipe thread and a relatively weak auxiliary sealing device.

Straight thread fittings and port connections are not a proprietary product or design. Although developed by Parker-Hannifin, they were immediately made available to the fluid power industry on a completely open basis.

They have been thoroughly field tested. In the severe service on mobile hydraulic equipment, today more than 6 out of 10 of the port connections are of the straight-thread type.

Now machinery builders and users alike are turning to this proved method of port sealing. Pipe threads for high-pressure hydraulic applications are fast becoming obsolete as more and more leading manufacturers recognize these advantages of straight threads in their production equipment:

No more wedging action with resulting distortion and breakage due to over-tightening . . .

No more messy pipe dope and the danger that it will infiltrate the hydraulic system . . .

No more leaks because of temperature changes or high shock conditions . . .

No more failures of costly auxiliary seals due to weak, imperfect threads that fit on thread run-out.

Why accept less? Next time you order high-pressure hydraulic components, specify Parker-Hannifin with straight thread port connections and fittings . . . you'll get leak-proof sealing—industry's recommended standard.

**Mobile equipment spool type control valves are all supplied with straight threads. Other components are still available with dry-seal pipe threads.*

HANNIFIN COMPANY
545 S. Wolf Road, Des Plaines, Illinois

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

Parker SEAL COMPANY
10567 Jefferson Blvd., Culver City, California

Parker HYDRAULICS DIVISION
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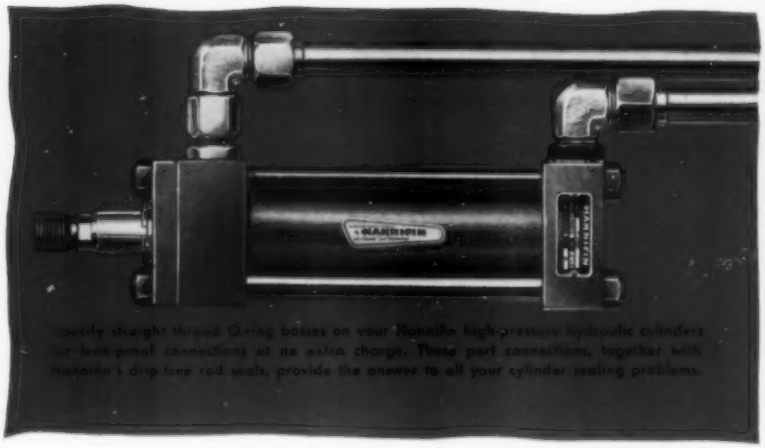
high-pressure hydraulic components

PORT CONNECTIONS...

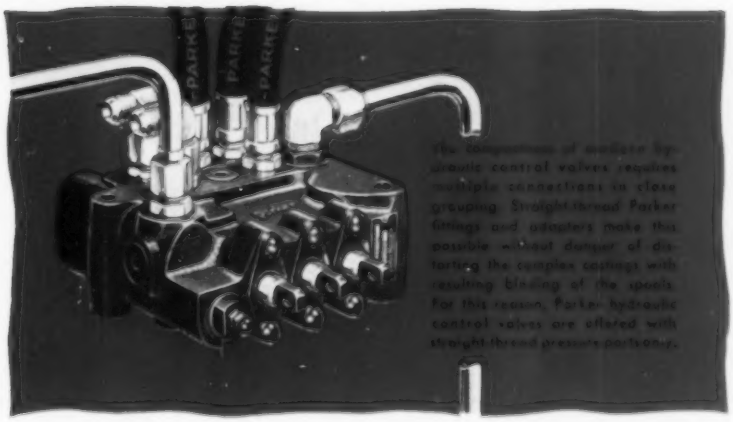


Specify straight thread O-ring bosses on your Hannifin high-pressure hydraulic cylinders for leak-proof connections at no extra charge. These port connections, together with Hannifin's drip-tree rod seals, provide the answer to all your cylinder sealing problems.

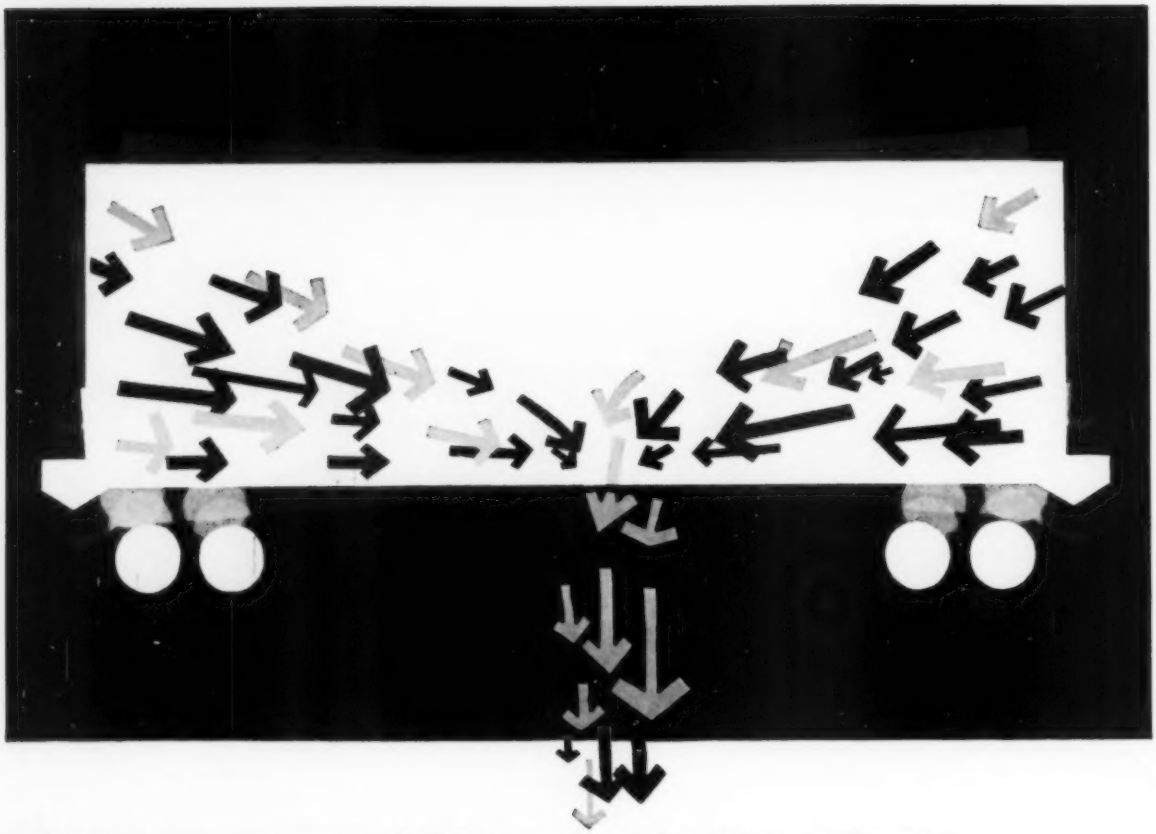
Both Parker's new "Hi-mo-loc" permanent and hose assemblies and "Hose-loc" reusable fittings as well as all adapters are available with straight threads. O-ring sealed for any specified fluid.

The O-rings used in Parker port connections are made only from service-tested Parker Seal Company compounds. With an ever-increasing number of fire-resistant fluids now on the market, it pays to avoid "jack-of-all-fluids" seals and stay with the Parker Seal compound specifically made for the fluid you will be using.

Here is a complete line of Parker straight thread O-ring fittings and adapters for you to choose from ... Triple-lok (flare type) and Parlok® (flareless, bite-type). Either method assures you leak-proof, trouble-free hydraulic connections.



The compactness of modern hydraulic control valves requires multiple connections in close grouping. Straight-thread Parker fittings and adapters make this possible without danger of distorting the complex castings with resulting binding of the spools. For this reason, Parker hydraulic control valves are offered with straight-thread pressure portions.

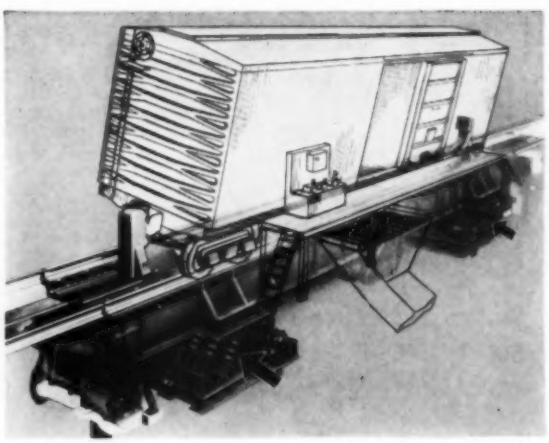


How to empty a full boxcar in ten minutes

Firestone Airmounts regulate the rocking action in Link-Belt's Kar-Flo unloader

Just 12 Airmount springs on the front and 12 on the rear are enough to help empty six full boxcars of bulk material per hour in Link-Belt's unique Kar-Flo unloader. Working like a set of bellows, they gently rock the car on air while controlling and amplifying the unit's up-down movement. With pressure supplied by a small compressor, Airmounts are always matched to the ever-changing load. For Link-Belt they mean a safe, rugged, easily maintained suspension that helps one man do the job of four in one-third the time.

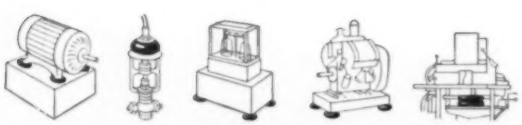
Firestone Airmounts—the same type air springs so widely used in trucks, buses, trains and automobiles—are finding many new industrial uses. Count on them to improve your efficiency and protect your property and products.

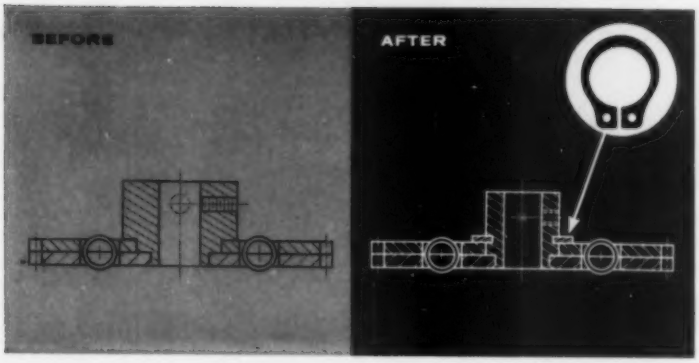


Unique rocking-on-air system conveys material simultaneously from both ends of car through door. Airmount springs support, control and amplify the movement.

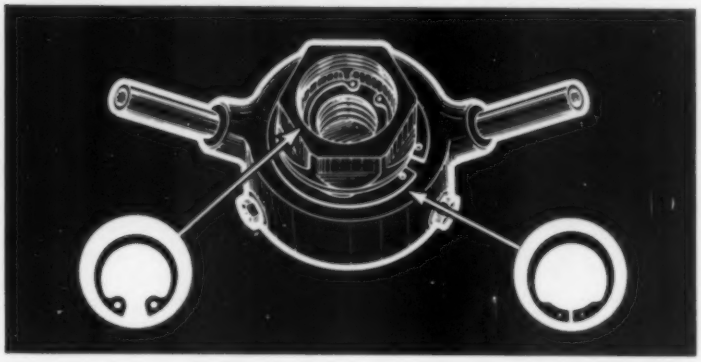
FIRESTONE **airmount**

Firestone Industrial Products Co., Noblesville, Indiana

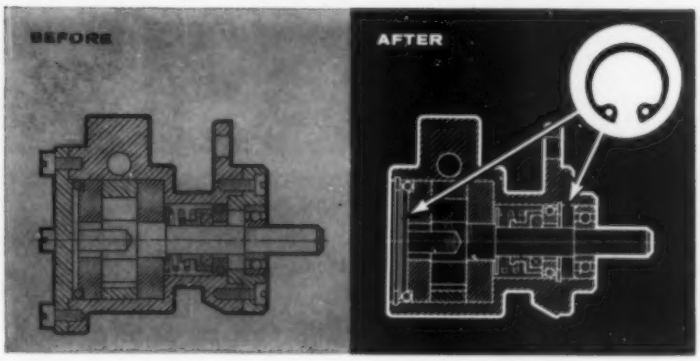




Gear assembly improved. A Waldes Truarc Series 5100 retaining ring in this anti-backlash gear assembly eliminates machining and staking operations, reduces hub size, and allows easy disassembly, after gears are cut as a unit, for faster, better deburring. **Typical savings: $350.00 per 1000 units.**



Threaded retainers eliminated. In this self-sealing coupling, costly internal and external threaded retainers were eliminated by easy-to-apply internal (Series 5000) and external (Series 5108) Truarc retaining rings. **Savings per unit amounted to $4.02.**



End-cover design simplified. In this general-purpose pump, two Waldes Truarc, Series 5000, internal retaining rings make possible the elimination of two cover-plate castings (plus machining) and eight screws (plus drilling and tapping). Weight and dimensions are reduced and assembly and disassembly are greatly facilitated. **Typical cost savings: $1.48 per unit.**

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WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor Inc., Long Island City 1, N. Y.

Designing for axial assembly with Truarc retaining rings

eliminates parts, machining, speeds assembly, simplifies maintenance

The proper application of retaining rings on or in axial assemblies can often effect startling simplifications and economies in design when compared to corresponding designs with conventional fastening devices. A few typical examples, using basic types of retaining rings, are shown in the accompanying drawings.

Threading, tapping, drilling, facing and other costly, time-consuming operations can be eliminated. Retaining rings are already in wide use in a tremendous variety of equipment ranging from household products to high-precision military gear designed for use under the most severe environmental conditions. They are quickly and simply installed in easily cut grooves which can often be machined simultaneously with other operations. The rings can frequently replace bulkier, more costly fastening devices —such as nuts, screws, studs, threaded sleeves and retainers, cotter pins, set collars, rivets and machined shoulders.

What's more, rings frequently make practical designs which could be achieved with no other known fastening device.

Although the ring types shown here are basic, Truarc retaining rings come in 50 functionally different types, as many as 97 different sizes within a type, 6 metal specifications and 13 finishes. You'll find detailed descriptions of Truarc retaining rings and assembly tools, plus more than 70 typical applications in the new 24-page catalogue RR10-58. Write for your copy today.

And remember, Waldes engineers are always ready to help you solve your application problems—whether it involves one of the standard Truarc rings or a "special" to fit your particular requirements. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

PHOTO BY KARSH OF OTTAWA

"Supplier reliability is a must to sound product development"

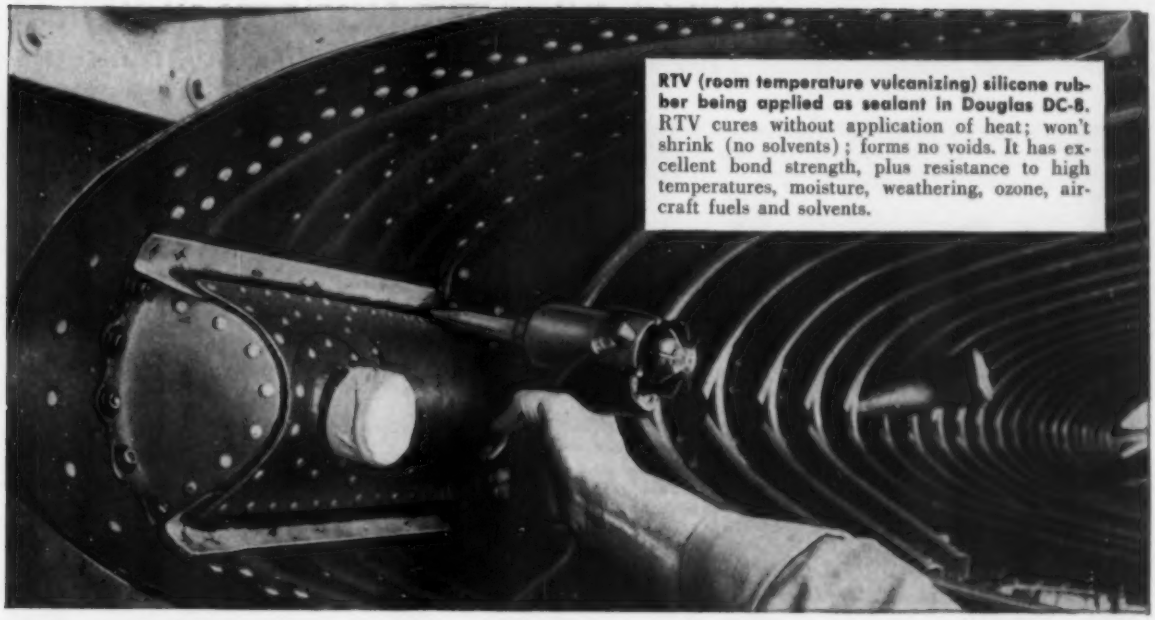
—R. W. SWANK, Research and Development, Smith-Erie Div., A. O. Smith Corp.

"We count Sharon Steel as one of our most dependable suppliers, and this is extremely important to a development engineer," says R. W. Swank, Manager of Research and Development of service station pumps in the Smith-Erie Division of A. O. Smith Corp.

Shown here with P. R. Fishburn, Manager of Manufacturing, Swank points out "If we can design with the knowledge that we need not be concerned about material analysis variation, our jobs are made that much easier. We've found we can expect this kind of supplier reliability from the *Sharon Steel Corporation, Sharon, Pa.*"

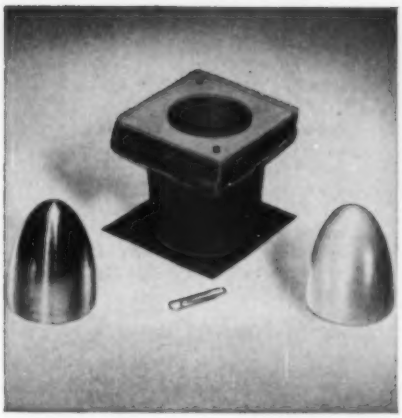
SHARONSTEEL **SHARON** *Quality* **STEEL**

CIRCLE NO. 32 READER SERVICE CARD



RTV (room temperature vulcanizing) silicone rubber being applied as sealant in Douglas DC-8. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

G-E RTV silicone rubber—a superior material for tooling, encapsulating and sealing



Prototype jet engine nose cone (right) cast in RTV mold. Epoxy parts cast in flexible RTV molds have a bright, glossy surface and reproduce extremely fine detail. No parting agent is required for even the most complex parts. High tensile and tear strength is retained even after prolonged heat aging.

Close-tolerance, non-standard helix gear cast complete in low-cost, one-piece RTV mold. Previously such replacement parts had to be machined by hand. Now they can be quickly and inexpensively replaced by using the broken part as a master.

Potting and encapsulating of electrical components, such as this aircraft transformer, are easy with RTV. It can be poured, sprayed, painted or applied by dipping. Temperature resistant from −60°F to +600°F; excellent resistance to high altitude arc-over and corona. Comes in wide viscosity range.

For application data and samples of General Electric RTV silicone rubber, write to General Electric Company, Silicone Products Department, Section A82, Waterford, N. Y.

GENERAL ELECTRIC

Silicone Products Dept., Waterford, N. Y.

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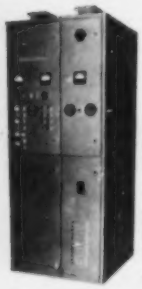
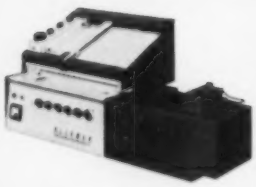


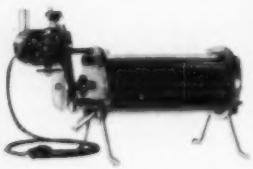
HURLETRON DC PRINTING PRESS DRIVE. "Years of experience with Bodine Motors in critical applications . . . plus the service of the Bodine Organization, gives us assurance of satisfactory performance." —Electric Eye Equipment Company.

SEEBURG SELECT-O-MATIC. "We require a motor that is quiet and free from vibration . . . and gives years of uninterrupted service in the field. Bodine Motors have satisfied all of these requirements for years." — M. W. Kenney, director of engineering, The Seeburg Corp.

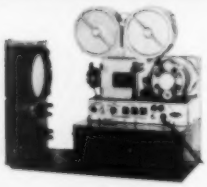
REMINGTON RAND AUTOMATIC CALCULATORS. "We require a motor with a high torque for its size. Bodine Motors meet this requirement without excessive temperature rise . . . and they're exceptional for reliability and performance." — B. H. Tingley, development engineer, Remington Rand.



BECKMAN ANALYTICAL INSTRUMENTS. "Bodine Motors are used in several of our precision instruments where critical specifications must be met and maintained. Twenty-four hour operation of our products is commonplace."—Beckman Scientific and Process Instruments Division.



KAY-CROSS OXYGENATOR. "The oxygenator must be of the utmost reliability since it takes the place of the lungs during critical surgery. We chose a Bodine Motor because of the high quality standards required. They have satisfied our needs very nicely." — Pemco, Inc.



GRASS OSCILLOSCOPE RECORDING CAMERA. "The Bodine Motor you designed for us far exceeds the performance of a competitive motor. We have used Bodine Motors for 24 years . . . and many motor application problems have been solved with the aid of your engineers."—Grass Instrument Co.

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Other applications for Bodine Motors: vending machines, communication equipment, sound recorders, automatic scales, respirators, voltage regulators, X-ray timers, traffic signal timers, stirrers, sanders, letter openers, envelope sealers . . . plus many, many other applications.

Bodine Electric Company,
2510 West Bradley Place, Chicago 18, Illinois

...the power behind the leading products

PERSPECTIVES

in design and development . . .

Nothing fails like failure

Less than 50% of all students who enter engineering schools are graduated. In Southwestern schools, this figure may drop below 20%. The countrywide average is probably somewhere around 45%.

Perhaps you've seen these figures before, so let's look at the other side of the percentages. Approximately 40,000 reasonably intelligent 17-year-olds waste, on an average, two of the most precious years of their lives in a fruitless attempt to become something they were never fitted to be or never really wanted to be.

The reason? Educational snobbishness. Nowadays if you don't have a college degree you're nothing. So a greater percentage of kids try college and, facing the spectre of their "undemocratic" failure, society forces the schools to easier and easier courses. The result is graduate engineers who cannot engineer and who are spoiled for anything else.

The "education debate" has produced few specific, workable suggestions, but here are some ideas, offered by an educator in response to our March 30 editorial on "Dialects in Engineering", that would apply equally well to most other areas of engineer-technician overlap:

Needed: professional draftsmen . . .

Maynard E Creed, senior instructor at the New Hampshire Technical Institute, writes us that the problem is one of prestige. "Engineering has all the glory, and until drafting is recognized as an end in itself, and so rewarded, the best young draftsmen will leave the field at the first opportunity—just when they've become most useful.

"Industry needs professional draftsmen—not flunked-out engineer hopefuls who have had 180 hours or less of 'engineering drawing'. A minimal course in drafting requires 1400 hours. The full rounding out of a draftsman requires years of experience as well."

. . . who can write their own standards

Mr Creed has some interesting things to say about drafting standards, "Too many 180-hour engineer/draftsmen think themselves qualified to set up drafting standards on their own. Note that the engineer is as uninformed in the language of drafting as is any other unspecialized user.

"Attempts at bringing order to drafting are organized for the most part by engineer/draftsmen whose training and experience are not specifically those of draftsmen. If drafting is a language, as we are assured, it must be made an effective, stable and standard means of communication by those who are devoted solely to that end. It must not be just a convenience for its users.

"The country badly needs a single drafting standard. But we don't need any new ones. *Any* standard would be more efficient than the confused collection now available to the working drafting room. Either American standards or military standards could be successfully applied on a national basis.

"It might deflate some organizational and personal egos, but I think the new Department of Defense Standard MIL-D-70327 and its supporting specifications are as good a set of drafting standards as are now available. . ."

The recommendations here are plain. Give the draftsmen the status and respect they deserve, then back them up with the responsibility and authority they need to do their jobs. —RMK

CASE HISTORIES

N/D achieves maximum axial and radial rigidity by matching two or three super-precision angular contact bearings having different contact angles. See figures 1 & 2 below.
FIG. 1
FIG. 2

Photo: courtesy Ready Tool Company

Bearing Design Helps Live Center Maker Achieve Accuracy of .000050"!

CUSTOMER PROBLEM:

Live center maker requires bearing design that will help achieve . . . and maintain . . . live center accuracy of .000050", under combination radial and thrust loads.

SOLUTION:

After thorough evaluation of the problem, New Departure recommended N/D pre-loaded, duplex ball bearings. Extensive testing proved these super-precise ball bearings resisted combination radial and thrust loads with minimum deflection. The N/D ball bearings, with medium and high contact angles, are mounted duplex and positively clamped together to assure the optimum, pre-determined preload condition. As work expansion increases the thrust load, radial centering becomes more rigid and accuracy is precisely maintained . . . to less than .000050" total indicator run-out!

When you're working on new designs that call for high precision ball bearings, why not call on New Departure? New Departure's consistent precision is your assurance of the ultimate in accuracy for your design. For more information, call the New Departure Sales Engineer in your area or write Dept. P-8.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Product Engineering HORIZONS

August 3, 1959

OUR MILE-LONG ECONOMY

We seem to be off on a nuclear-design kick based on the mile instead of the inch—witness the current Lockheed and Convair reports of space ships to be towed by mile-long cables from nuclear power plants. It's lucky that cable is weightless in space so the catenary curve can be neglected, but what happens when the "buggy," which is a-mile-of-harness behind the "horse", approaches a stop?

Or again, take the two-mile-long particle accelerator we're going to put through a California mountain. The accuracies involved are in the familiar ten-thousandth-inch range, which means that at least a mountain is necessary to hold the elements in accurate alignment.

Are such designs nceessary? Granted we're building in accordance with the best available knowledge, but isn't there a more-practical shielding method than distance, or a more-practical acceleration method than a 2-mile straight line? At the risk of sounding like a scientist, who never wants to freeze what he's discovered into workable or saleable hardware, are we crawling toward answers to which it's only practical to walk?

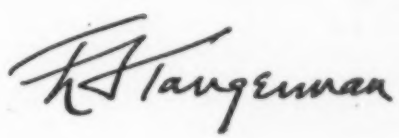
While we're dealing in these long-distance concepts that in a way apologize for incomplete development, are we missing some fundamental flaw in our reasoning or knowledge? Are we basing our plans on some "fact" that isn't factual at all?

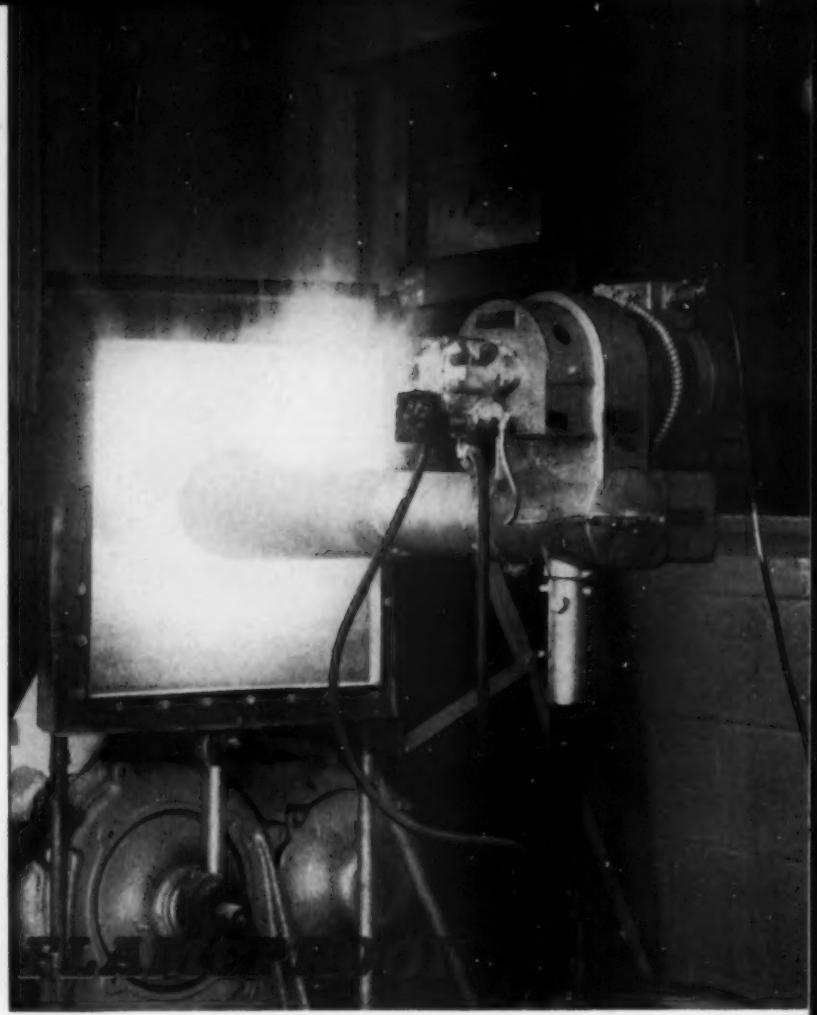
These questions are raised by a recent disturbing announcement by Dr Edwin H Land of Polaroid. He comes up with research that at least seemingly proves that Newton's theory about color is just a theory, that what we see as color is not a function of the wavelength of the impinging light at all, but rather one of two different wavelengths impinging simultaneously. Dr Land produces the full spectrum of colors with only two black-and-white photographs, one taken through a red filter, one through a green. The one taken through red is projected through red, the other is projected without a filter. When superimposed, the two images give the viewer a full-color picture.

There are all sorts of possibilities shown by the discovery, immediately applicable to color TV but later suggesting a whole new approach to color and color analysis.

But there's more to it than that. Two Americans discovered all this in 1914 and got a patent on it—then dropped the whole thing because it was so contrary to Newton's "laws" that they saw only trouble ahead. An Italian hit upon it again in 1925, and again decided to tiptoe quietly away because it challenged the "facts." Here was Opportunity knocking as often as a rent collector—and getting the same treatment.

How many of our other laws are just theories? How many other designs are based on mile-long thinking that misses the close-up facts? How many of us are following the sage advice about seeing the woods, and missing the vital fact that a forest is really many single trees?





Special design problems . . . call for special flammability tests like this one which measures resistance of new Johns-Manville Firewall Cloth to vibration as well as heat. Another, pictured on the cover of this issue, uses a jet torch to ignite ablation materials. But most materials flame far more readily, are tested by ordinary torch or induction coil, as shown by photographs on opposite page.

WHEN YOU HAVE TO FLAME-PROOF A PRODUCT

Fire means trouble. Whether your product started it, spread it, or simply was wrecked by the heat—your company has troublesome questions to answer. But just what do "flameproof" and "fire resistant" mean? And how can design best meet the demands for fire safety? Here's the latest on flammability tests and treatments.

ANNESTA R GARDNER, *associate editor*

Nobody likes to see his handiwork go up in smoke. But when the specification calls for a "flameproof," "flame-resistant" product—or for "flame-retardant" materials—watch out.

Not that there aren't design procedures that will reduce flame hazards; and there certainly are materials that will resist burning. The trouble lies in defining the terms, finding the test methods, and interpreting the results. There are no universally accepted definitions for any of these terms, few broadly applicable tests, and there's very little agreement among laboratories on the results of tests they do approve.

Even the way a material is put together can give different results. For example, the Building Materials List issued by Underwriters' Laboratories gives glass-fiber blankets with aluminum-foil facing a flame-spread rating almost twice as good as that for plain glass blankets; while glass mats coated with neoprene or vinyl resins receive a rating barely half as good.

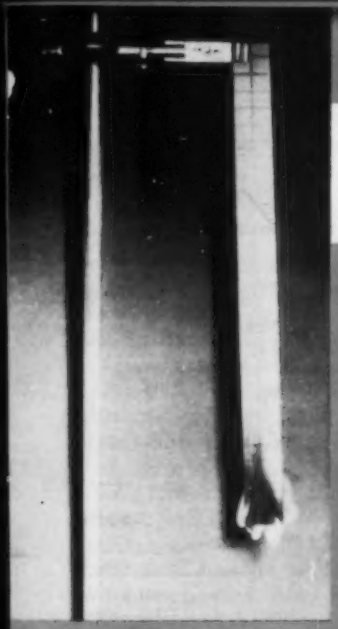
Still, there are materials that will serve to increase flame resistance; and there are design rules that will help.

Defining the Terms

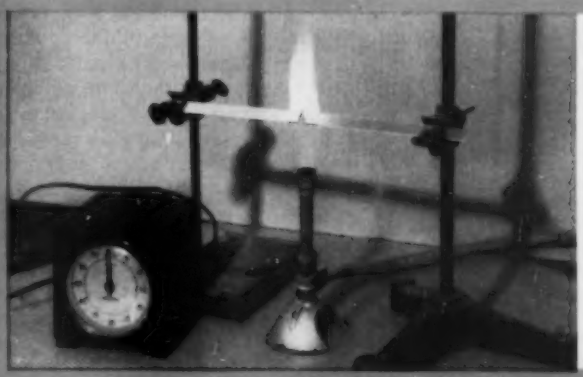
If all specifications were based on flame spread or resistance to burning for a given period of time under a clearly stated, reproducible set of conditions, all would be well. But there are literally dozens of tests, and dozens of definitions. It is fairly generally agreed that a "self-extinguishing" material is one that will not support combustion when the ignition flame is removed. But some give the same definition for "flame-resistant" and "flame-retardant"; while others try to distinguish between the three

To compound the confusion, new "twilight terms,"

(CONTINUED ON PAGE 40)

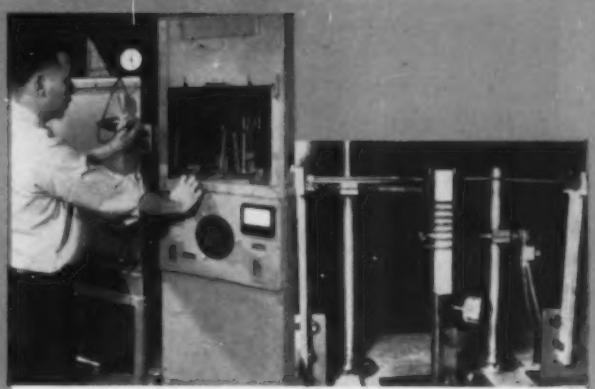


Standard test . . . for materials 0.050 in. thick or less, is demonstrated here by GE's Laminated Products Div. Material is suspended vertically, ignited by pyroxylin fuse, allowed to burn until consumed or until fire goes out. Duration of burning and amount consumed are reported as test results.



For thicker materials . . . 50 mils or more, samples are held horizontally for Federal-ASTM test. Some use single support; but others support samples at both ends, as here in Synthane Corp lab. Flame is applied for 30 sec; then removed and reapplied if flame goes out. If sample resists burning the second time, it is labeled "self-extinguishing."

Radiant panel test . . . originally developed at National Bureau of Standards for building materials, is now widely applied to plastics for product use. Specimen is supported at 30° angle to porous refractory panel which serves as radiant heating unit. Time of arrival of flame front at specific points, and amount of heat evolved, are both measured; and are used to compute flame-spread index. This photo was taken in US Testing Co lab.



Rigid plastics . . . undergo test in this apparatus under Federal Specification 2023. They're surrounded by heater coil held at 860 C. Spark gap is provided above coil to ignite any evolved gases (note closeup, right). This Navy-developed test is being used by several industrial laboratories like those at Synthane (left) and GE (right) as well as military installations; forms the basis for a major effort now in progress to obtain comparable reproducible results.

HOW TESTS ARE MADE

There are literally dozens of flammability tests which have attained the status of trade-association or technical society standards, or have been incorporated in military specifications. These tests differ in setup and procedure; they express results in different terms. Some specify *rate* of flame spread; others measure *distance* the flame travels; still others measure time of burning. ASTM E69-50 for wood products measures *weight loss* during burning. A textile test gives its results in terms of *glow* resistance.

Some tests state results in actual numbers; others use an index. For instance, a rating of "20" on the SPI plastic film tests means it took 20 sec for the flame to reach the upper string. But a flame-spread rating of "20" may also refer to an entirely different test, used by Underwriters' Laboratories, and calling for test panels 25 ft long. Here, the rating means the material has a relative flammability of 20 on a scale in which asbestos board is 0 and red oak lumber is 100.

Because tests developed for plastics in many cases stem from, and are applied to, other materials, it's worthwhile to take a close look at them. Pictured and described above are four of the tests most widely used. Even for these, reproducible results are difficult to obtain even within one laboratory, much less among laboratories, though identical test equipment is used. This is because many variables enter into the burning process.

The great range between the top and bottom of the flammability list is another problem in testing; often "solved" by changing the test. For example, flammable materials are usually tested in a device which holds them in the horizontal position. But this slows down flame spread, so some laboratories test the more-resistant materials at a 70° angle. Heavy, solid materials, like bars of laminated plastic, are tested in vertical position so they can burn freely.

Because of all these problems, it is not surprising to find each specification carrying its own test procedure—and still find considerable confusion and disagreement. The specifications listed in the box on p 41, though, are widely accepted.

11 Ways to Increase FLAME RESISTANCE

To make products *resist* fire:

1. **Use materials that won't burn and will not start fires by sparking or ignite by spontaneous combustion.**
2. **Avoid very thin materials and powders.** Metal foils, gauze-like textiles and paper flame much more readily than thick sections. Many metals are pyrophoric (ignite spontaneously) in powder form; but are quite safe when made into solid castings or forgings
3. **Avoid thin sections or delicate projections** which can serve as kindling to get a fire started.
4. **Avoid materials that form a hot melt** when exposed to high heat. (Some plastics vaporize completely; others form droplets that may aid the fire to spread.)
5. **Make sure that shelf life of flame-retardant additives is adequate** (that they will not deteriorate or evaporate in a relatively short time); that they will not leak out or dissolve out; that they will not adversely affect the performance or appearance of the material to which they are applied; and that they will not attack adjacent materials.
6. **Use flame-retardant paints and coatings** where the materials themselves are not flame resistant; but observe the same cautions as above.
7. **Avoid channels that may conduct flame** from one section to another or that help fire to jump across nonflammable areas that would otherwise help to extinguish the flames. Keep major planes horizontal if possible so flame propagation will not be aided by convection.
8. **Avoid pockets** that may collect dust or lint, and make those which are necessary (e.g. lint traps in automatic washers) self-cleaning.
9. **Use fire walls** or bulkheads between major sections.
10. **Incorporate heat sinks** that will dissipate heat buildup in plastic parts.
11. **Check small components** like seals and gaskets to make sure they equal major sections in flame resistance.

subject to many shades of opinion, are beginning to creep into discussions and specifications. "Slow-burning" is one example, used recently in discussions of thermoplastics for air-conditioning equipment. "Slow" in relation to what? Under what conditions? As applied to which materials?

The place where a piece of equipment is to be used may be as important as its construction when it comes to gaining approval by the UL. Says this agency: "Each class of devices must be considered separately in establishing requirements . . . It is often necessary to apply different requirements to parts used for different purposes, as well as for parts used in different locations within the same device."

These Can't Be Measured

Furthermore, some of the most important qualities are not subject to direct measurement, though they can and should be observed.

Does the material evolve unusual amounts of toxic gases or form toxic compounds when burned?

Will it form a hot melt or drip that may endanger other products, or does it simply char or volatilize harmlessly?

Is the product itself so designed that it will channel flame to otherwise safe areas?

Is too much flame resistance being provided? Will a simple fire-barrier coating do the trick? These can serve only once; but they may protect the inside of the product even thought the housing must be replaced. Some form a hard, glassy fire barrier. Others foam up, and stop fire for a time, but in the end are consumed themselves. Still others give off non-combustible, fire-blanketing vapors.

Relying too heavily on flame tests of basic materials may also hamstring design unnecessarily. A relatively flammable material, unacceptable for an exposed housing or grille, might be perfectly safe for use deep inside a product where it would be unlikely to catch fire or where an ysmall flame would quickly be self-extinguished. (The reverse may also be true where there is danger of electrical ignition inside the product.)

Five Points to Watch

1. Flammability does not correlate closely with other properties—mechanical, physical, or electrical—that may be under consideration. Furthermore, some materials take more readily to flame-retardant treatments than others; and, after treatment, a highly flammable material may outperform a slower burning material. Epoxy resins are a good example. Untreated, they burn readily—much faster than phenolics. But the epoxies take readily to flame-retardant treatments, so good-quality self-extinguishing materials may be had at only slight additional cost. The phenolics, on the other hand, are harder to treat. It is only recently, for instance, that satisfactory self-extinguishing XXXP grades have been marketed (*PE*—*May 26 '58, p 19; Oct 20 '58, p 5*).

2. The form in which a material is used may be almost as important as the treatment it's given. Metals which flare readily in powder or thin foils resist burning in solid form. Heavy papers and tightly woven textiles also differ a great deal from lighter constructions when it comes to flame resistance.

3. The flame-resistance of a material or part can be greatly reduced and a "flameproof" component turned into a firebrand by treatments it is given for other reasons. Resins applied to glass fabrics, to reduce abrasion, may provide a path for fire. Paints and coatings of all kinds, applied to improve appearance or retard corrosion, may greatly increase flammability. The same is true of impregnants intended to retard the growth of fungi or seal against gas penetration. Lubricants and hydraulic fluids can be a source of trouble unless specially formulated.

Furthermore, the flame-retardant treatment itself may

affect the properties of the treated material or attack adjacent parts.

4. "Accessories" like liners, gaskets, and shims can create trouble in a product otherwise resistant to fire. The lining of an instrument case, the backing of a radio, even the tape of a recording unit can be a troublemaker.

5. The over-all design of the product itself may contribute to flame resistance—or lack of it. Simple firewalls can often help reduce flammability. Channels provided for other purposes may become a path to "pipe" flame to otherwise "safe" areas. Such devices as lint traps should be self-cleaning wherever possible to avoid spontaneous combustion as lint accumulates.

What to Do

When specifications are at hand, and design goes to work, the first step is to request test results from suppliers of components and materials, and formulators of flameproofing materials. But also be prepared to make your own tests as well, on materials in the form in which they'll be used. Test the insulating tubing, not just sheets of the raw material; test the coated magnetic tape, not just the backing film or paper. A surprisingly small change in structure or composition can make a big difference in flame-test performance; and a material that fails on its own may pass muster in combination—or the reverse (*PE*—June 1 '59, p 15).

But tests results are a guide; not a gospel. Almost everything will burn if the fire is hot enough. The goal in flameproofing is not perfection; but simply the development of products that, under normal conditions, will resist burning for a reasonable length of time and will make the minimum contribution to feeding the flames of fires that have already started.

What's Ahead?

As far as testing goes, the situation may get worse before it gets better. Much is being done to standardize tests. But each new crop of specifications, commercial as well as military, brings new modifications or off-line requirements that mean well in attempting to solve a specific problem but actually add to the over-all confusion. On the other hand, organizations such as those listed here are making an effort to standardize tests and improve their reliability.

Much work is being done, too, to develop materials that are better able to resist burning.

New organometallic and phosphorous compounds promise more effective and more durable coatings and impregnants (*PE*—Apr 14 '58, p 19). Research on built-in flame retardants—materials that can be polymerized into plastics and fibers so they are truly permanent—is beginning to pay off. Stanford Research Institute, for instance, claims a "plastic that won't burn." This is a high-chlorine copolymer (polytrichloroprene) that SRI says "will not support combustion." New basic materials with great heat resistance—inorganic resins, among them—are in the laboratory. Research is being pushed by industrial laboratories as well as military organizations like Wright Air Development Center. These are long-term programs. Resins so far developed lack many needed qualities. But the long-range outlook is good.

For REPRINT of above article, just check E97 on one of the Reader Service cards bound in this issue.

Where to get information on flammability

● Primary sources of information are individual suppliers of materials and components, manufacturers of flame-test equipment, and the individual government agencies for which the product may be designed. While there are over-all Federal Specifications (LP-406b for plastics, for instance), no rules say these must be followed in any specific case, and each new military or Federal standard may carry its own requirement and its own test. Here is a roundup of some of the more helpful government and nongovernmental sources:

GOVERNMENT

Federal specifications, including those mentioned on p 39, are obtainable from Government Printing Office, Washington 25, DC. Federal specification LP-406b, incorporating methods 2021, 2022, and 2023, is 50¢. Dept. of Commerce Commercial Standards, including CS 192-53 (vinyl plastics), are 10¢.

Military specifications are usually available without charge from the issuing agency; but the interagency repository is: Naval Aviation Supply Depot, 700 Robbins Ave, Philadelphia 11. Typical of the specifications available from this source (and a good example of an off-line flame test) is MIL-I-21557 (SHIPS) —Insulating sleeving, electrical, glass fiber, vinyl-treated.

The National Bureau of Standards publications are available from Government Printing Office. Many of those now available deal with building materials, but others on engineering materials, are being readied, will be available from the same source. Prices range generally from 10¢ to 25¢.

INDUSTRY:

American Society for Testing Materials: A series of standards, available individually at 30¢ each, covers testing of plastics (D568, D635, D757, D1443), textiles (D626), paints (D1360, D1361), paperboard (D757), and electrical insulation (D229, D350, D876). Other publications, at prices to 60¢, are also available.

Association of Casualty & Surety Companies: An excellent series of survey reports on flammability is available, but only on request through member concerns.

Society of the Plastics Industry: Information on specific tests, plus general background.

National Electrical Manufacturer's Assn: NEMA Committees are at work on new tests, especially for laminated plastics, but there are no final standards as yet.

Underwriters' Laboratories: Much information on relative flammability of materials and products is contained in UL equipment listings, especially the Gas and Oil Equipment and Building Materials lists, obtainable from UL offices in New York, Chicago, and Santa Clara, Calif.

National Fire Protection Association: Standards, codes, and other publications on fire safety, particularly in regard to product performance rather than design. One reference worth having: "Fire Tests for Building Construction Materials" (50¢); it describes a test also used by UL, and lists related NFPA publications. ●

TRANSISTORS / *the 6 basic types* • • •

Even though transistors come in scores of varieties, six basic methods of construction cover almost all types. Here's a look at these methods and how they influence performance.

HARRY GOFF
Semiconductor-components Div
Texas Instruments Inc, Dallas

There are few electronic systems today that don't have transistors some place in the circuit. Over 45,000,000 transistors were put to work in 1958, and the trend is growing. Therefore, not only the electronics expert, but also the product designer, has to know what the transistor is and how it can fit into the design of a product. Some familiarity with the basics can be sufficient to make that important decision of whether or not to transistorize a control.

A previous article, "Transistors vs Electron Tubes for Industrial Applications," Oct 28 '57, p 52, gives typical performance of a junction transistor–for each of three circuit configurations: common base, common emitter, and common collector. However, external circuitry has such a great influence on resistance, frequency, phase and amplification of a transistor that precise limits are impossible to set unless the application is defined. Textbooks adequately cover circuit performance as well as theory of transistors; therefore, only this important terminology will be repeated here:

• **Transistor**–a solid-state device, with at least three elements, capable of amplifying, rectifying or acting as an off-on switch. It is made with semiconducting materials, such as germanium and silicon, which have electrical resistance between that of gold and of glass when minute quantities of certain impurities are added.

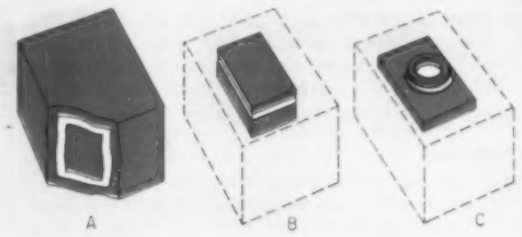
• **N- and P-type impurities**–materials added to the fundamentally pure semiconductor material to give it the characteristic of either wanting to give up electrons (N-type "donor") or accept electrons (P-type "acceptor").

• **Emitter**–transistor element that emits current. It usually has a function similar to the cathode of a conventional vacuum tube because it is the source of current flow.

• **Collector**–transistor element that collects current. It is similar to the plate of a vacuum tube because it picks up the current supplied from the emitter (cathode).

• **Base**–transistor element that can electrically induce the emitter to pass current to the collector. It is similar to the grid of a vacuum tube because it controls the flow of current between emitter and collector. However, the control signal required is current, while that for a vacuum tube is voltage.

All transistor devices can be described by one of the sketches on the opposite page (oldest type at top, newest at bottom), or by a variation of one of them.

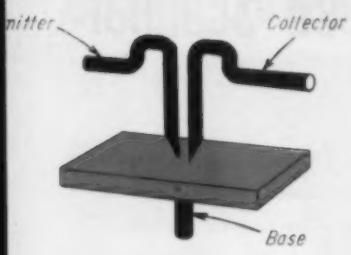


Three steps . . .
are needed to make the sandwich for a diffused-base transistor (opposite page). Step A—A P-type and then an N-type layer is diffused into an N-type wafer; Step B—Sides are lapped away; Step C—Etching technique gives final shape desired.

EDITOR'S NOTE: The characteristics of transistors, switching diodes, thermistors, solar batteries and other solid-state devices are summarized in "Semiconductors—Revolution at Your Elbow," Apr 14 '58, p 60.

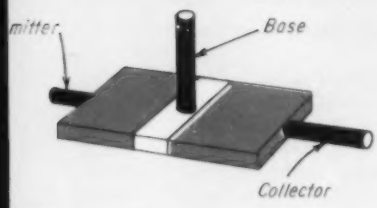
METHODS OF CONSTRUCTION—how and why they differ

Sketches (not drawn to scale) show main features of assembly—with N-type material in color.



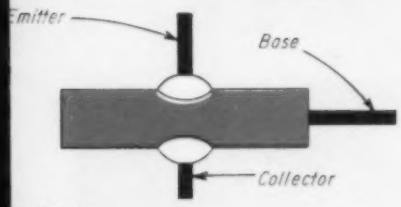
1 Point contact

This transistor was the original design—a breakthrough made by Bell Laboratories in 1948. It is essentially two diodes (rectifiers) back-to-back. Current is normally blocked between emitter and collector in both directions because one or the other of these diodes will be nonconducting. The transistor action occurs when a control current is passed into the base. The adjacent diode (emitter) then becomes a conductor and allows current to flow from emitter to collector. A point-contact transistor is limited in gain and power by the small area of contact, and is difficult to manufacture.



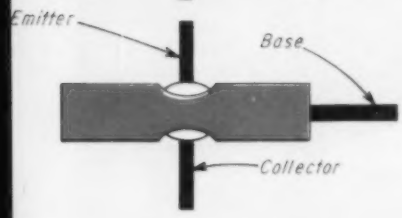
2 Grown junction

This type obtains greater "barrier" area by doping the germanium or silicon crystal with the appropriate "N" and "P" impurities during the growth of the crystal. The large doped crystal is then cut into tiny rectangular bars which become transistors when electrical terminals are attached as shown in the sketch. This design has obsoleted the point-contact transistor, and now accounts for the major portion of transistors made for high frequency. A limitation is that transistor size and power depend on grown-crystal size.



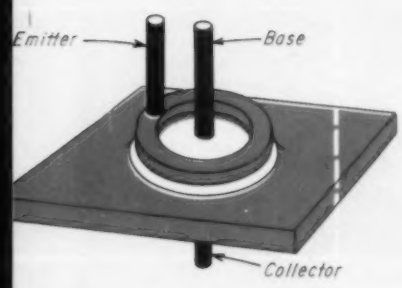
3 Alloy junction

Such transistors, which can be larger than preceding types, have a sizable "dot" of P-type material alloyed into each side of a single N-type crystal wafer. Alloying is done in a high-temperature hydrogen furnace. The increased junction area improves power capability, but lowers the useful frequency. Major application is in audio-frequency range, for radios and computers.



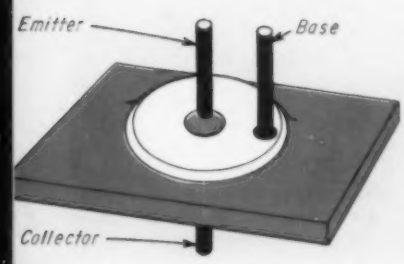
4 Surface barrier

These are similar to the alloy-junction design, except that depressions are etched out electrochemically to give a controlled base width. Then P-type dots are plated into the depressions. Higher frequency of response—without loss of power capabilities—is the result.



5 Diffused base

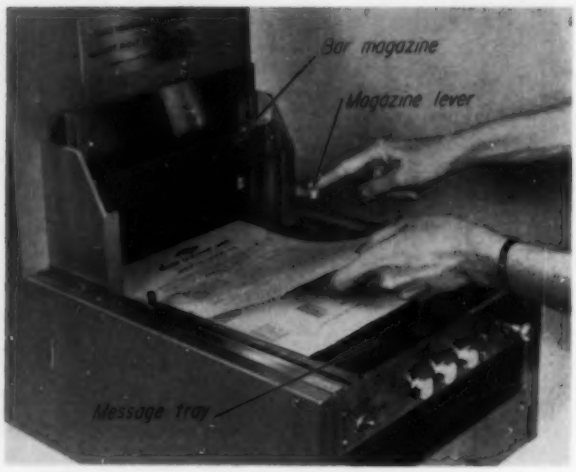
Both diffused base and alloy-diffused base transistors combine most advantages of the previous three designs, but at some increase in cost. They are called "mesa transistors" because they resemble those flat-topped hills with sloping sides. Their virtue arises from the diffusion technique of manufacture—a technique in which the layers are formed by diffusing the N- and P-type impurities by gaseous means into the surface of the crystal—a kind of case-hardening mechanism. Layer thicknesses of less than 0.0001 in. over any area are possible, and therefore a variety of transistor properties can be chosen. Some devices on the market can dissipate 85 watts; others switch on-off-on in less than 0.1 microsec at low power; and some act as amplifiers up to 1000 megacycles.



6 Alloy-diffused base

This mesa-type transistor is made in one diffusion step. It substitutes an alloyed dot for the outer diffusion layer. It is otherwise similar to the diffused-base version.

Flat-bed Scanner



Automatic loading on flat bed makes it easier to send copy and illustrations by wire. Up to 22 messages may be loaded initially or during operation. Mechanical light equalization simplifies optics and maintenance.

Inherent advantages of flat-bed transmitters are: rolling and wrapping are eliminated; clips or other restraints are not required to hold the message; and drums need not be changed. Because the message is not curved around rolls, handling of cards or nonflexible copy is possible. Facsimile Transmitter WM207 was designed by The Western Union Telegraph Co, NYC.

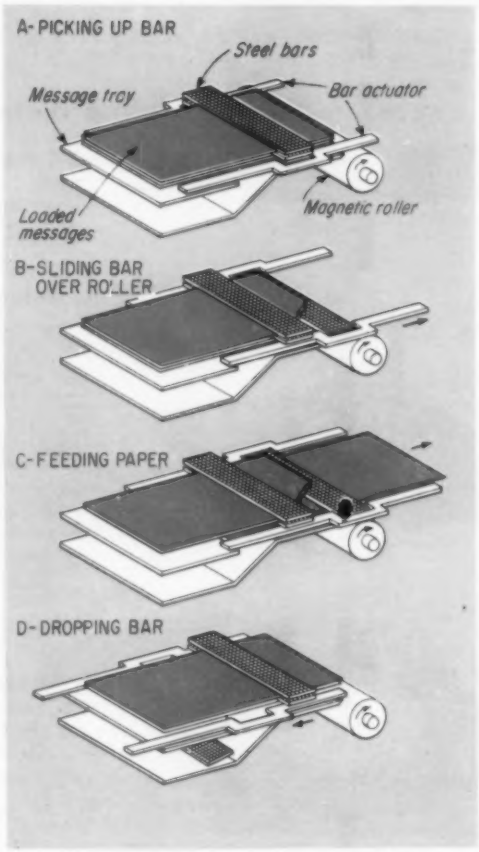
To load the transmitter . . . paper copy is placed face up on the felt-covered message tray. Copy is indexed against right side of tray and against curtain under the bar magazine. When operator depresses the magazine lever, a bar drops on top of the copy. Same bar trips a switch to initiate the loading operations.

The loader motor operates the bar actuator (A) causing it to move the bar over a rubber-tired magnetic roller (B). During this movement the paper beneath the bar remains stationary because of its loose contact with the bar. A paper-detector circuit is energized to be sure that paper is under the bar before signal is sent to the recorder, starting the paper-feed (C) and scanning sequence.

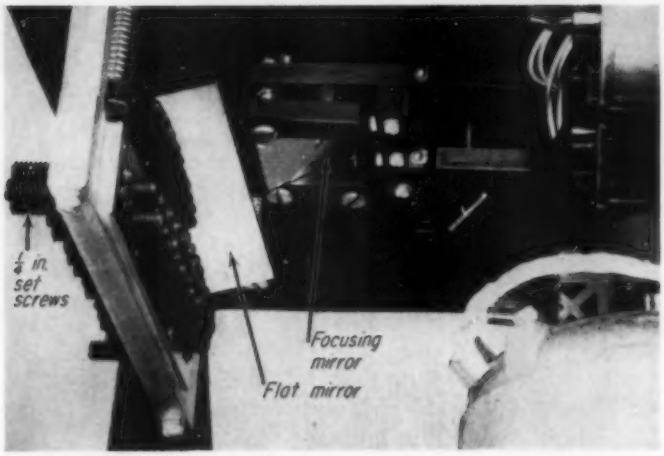
During this sequence the copy being transmitted is squeezed between the steel bar and magnetic roller. The bar is restrained by magnetic attraction and message is forced forward by rotation of the roller. A rear feed roller beyond the scan line pulls the copy on through the transmitter. After the message has been transmitted, actuator moves the bar over a slot (D) and drops it into a storage bin beneath the message tray.

Fast paper feed is used to economize line time by quickly bringing the sheet to the scan line before scanning at the normal speed and by quickly removing it afterward. In addition, long rolls of page teleprinter copy can be continuously transmitted.

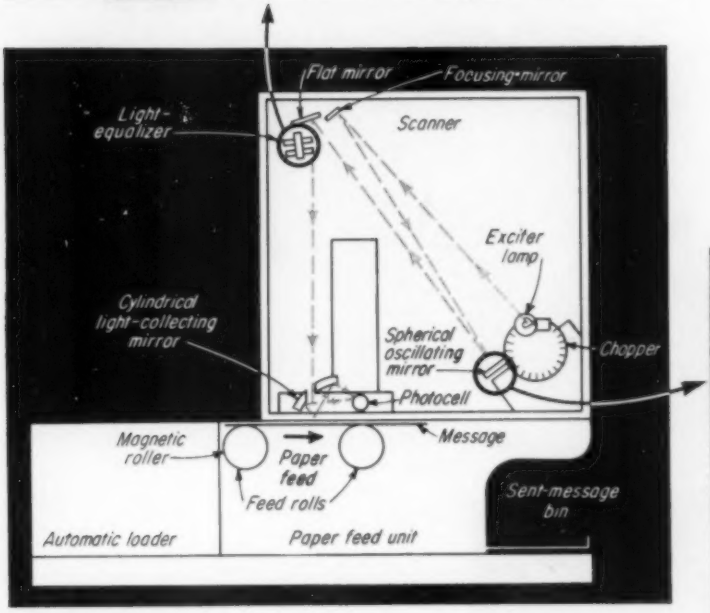
This machine is designed to operate at either 180 or 360 scans per minute. A significant advantage is realized in the case of changing mechanical speeds simply by throwing switches. Output may be adjusted for either white or black maximum.



Uses Flying Spot of Light

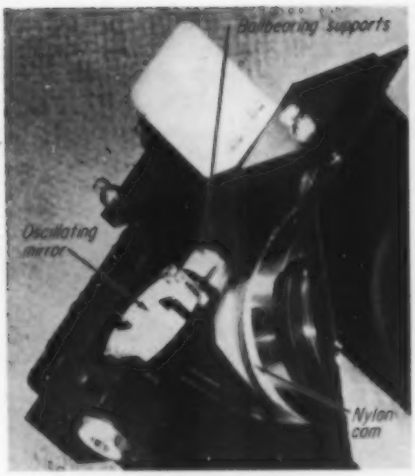


Photocells . . .
may not be uniform in sensitivity along their length, nor is pickup from the collecting mirrors necessarily uniform—hence the need to correct light-intensity variations along the scan line. This is done by a mechanical equalizer using ¼-in.-dia setscrews. Each setscrew interferes with and partially blocks out a portion of the light beam before it reaches the scan line. Since the screws are located midway between spherical mirror and scan line, the shadow of a single screw is spread over an appreciable length of scan line during the sweep. This effect, when combined with similar characteristics of adjacent screws, makes possible a smooth equalization.

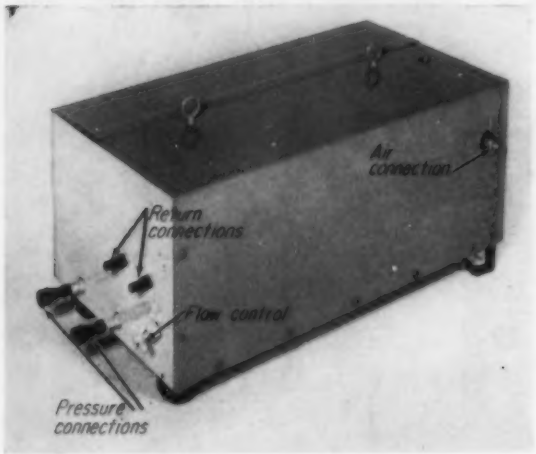


Scanning system . . .
consists of a light beam, 0.010 in. dia, produced by a tungsten arc and lamp reflected onto the paper by four mirrors. Three mirrors fold the optical path, reducing size needed for the scanner and simplifying adjustment. The fourth mirror collects light from the arc lamp and focuses it onto the photocell.

The 0.010-in. spot of light is swept back and forth across the copy at a uniform rate by oscillating the spherical mirror. This scanning operation is repeated continuously while the copy advances uniformly past the scanning line. Light reflected from the copy is focused by a cylindrical mirror onto the cathode of a photocell which converts variations of light intensity into proportional electrical currents. Paper feed is synchronized so that paper advances 0.010 in. for each sweep of the beam. Therefore, intelligence is treated as discrete strips 0.010 in. wide.



Scan line . . .
is generated by the concave spherical mirror mounted in ballbearings and oscillated by a motor-driven nylon cam. Cam motion causes the spot to sweep across the copy during 95% of each revolution, leaving 5% for retrace or flyback.



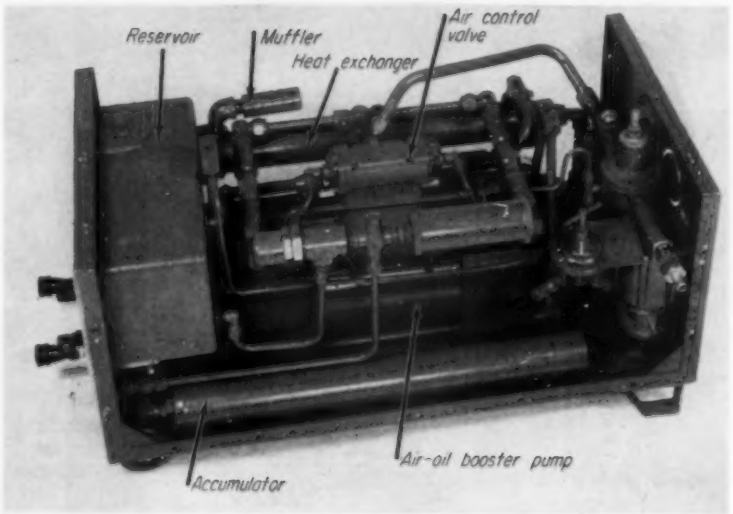
Portable air-oil booster provides hydraulic power where needed. The all-mechanical unit eliminates electrical motors, relays and switches.

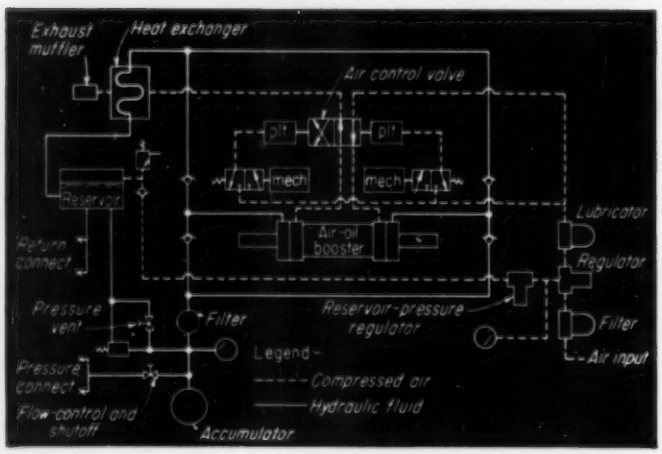
Unit can be used to power all types of hydraulic components: fastening tools, broaches, drills, reamers, punches, jacks, clamps, etc. Explosionproof "Pack Horse" is 31 x 16 x 15 in. It pumps 3.5 gpm, at up to 3000 psi with 85.7-psi air pressure. Produced by M B Sturgis Inc, St. Louis.

Pneumatic Power for Hydraulic Tools

Booster pump . . .
consists of a large air piston with a small ram piston at each end. Difference in areas of the air piston and ram piston determines pressure boost obtainable from the pump. Air piston, 6 in. dia, and ram piston, 1 in. dia, produce a 35:1 boost ratio.

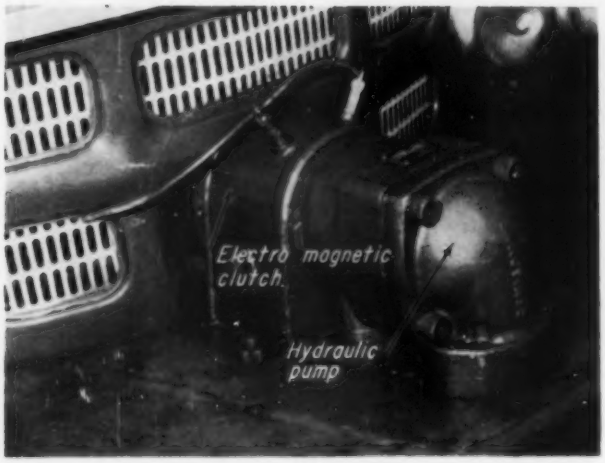
Air supplied at 100 psi produces a 3500-psi working pressure to balance the pump statically. Air piston remains in this static position until a demand in the high-pressure section drops the pressure. This upsets the static balance and the pump goes into operation, continuing until a balancing pressure is again built up.





Air piston . . .
is reciprocated by a 4-way valve that ports outlet air to one or the other side of the piston, depending on position of the booster. This valve is shifted by means of pilot actuator valves within the booster. When air piston reaches end of its stroke in one direction, it contacts the actuator and pressure is ported, shifting the spool so that the air piston is driven in the opposite direction. When air-oil pressures are not statically balanced, the air pistons reciprocate—continually causing the ram to draw in and pump hydraulic fluid through the check valves. The expanding exhaust air from booster is passed through heat exchanger to cool the hydraulic fluid.

Trailer Pushes as Tractor Pulls

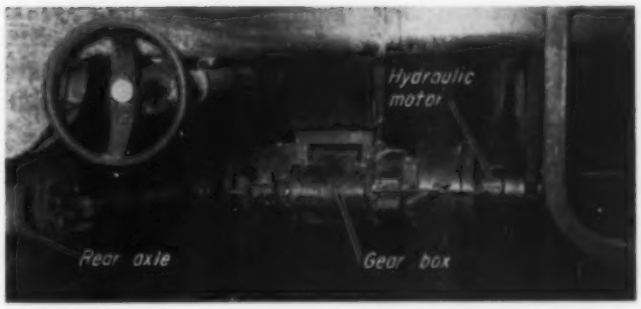


Excess power available at low speeds is transmitted to motorized trailer axle to keep rig moving. Over-running clutch cuts out rear axle power at higher speeds.

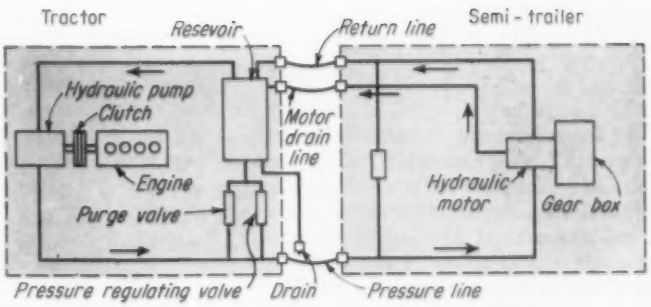
Intended for use in the Sahara Desert, hydraulic motor on rear axle keeps tractor-trailer moving over roughest terrain. Tractor-trailer shown is loaded to a gross weight of 29 tons yet moves easily through deep sand. Hydraulic rear-axle assist is manufactured by LeMoteur Moderne, Paris, France.

Semitrailer power . . .
is supplied by a hydraulic vane pump driven by the tractor motor. Hydraulic motor on trailer drives rear axle through a two-speed gearbox. Pump is linked to tractor engine by an electromagnetic clutch controlled by a switch on the dashboard.

The pump uses about 60 hp of the 150 hp produced by the engine. Result is sufficiently reliable power for the tractor wheels. For example, in rough country, at lower gear ratios, the engine operates well below its maximum output. The hydraulic motor on semitrailer develops 50 hp. Two-speed gearbox plus reverse incorporates an overrunning clutch that limits power transmission to one direction only.



Dual independent connections . . .
exist between pump and motor. One is the hydraulic tubing between the units; the second is through the ground. Power cannot be transmitted to the semitrailer axle unless the volumetric output of the pump exceeds that of the motor. Since the volumetric requirements of the motor are a function of the speed of the rear wheels, the rear axle actually draws power as needed. At speeds in excess of 12 mph the overrunning device cuts out rear axle power completely. Selfsealing quick disconnects on the flex-couplings plus a valve on the trailer permit the units to be uncoupled.



what you should know about

DRY-FRICTION DAMPED ISOLATORS

Though they can outperform the better known "viscous" type, they cause trouble at higher frequencies unless properly selected. With curves comparing both types, the author supplies his own equations for predicting vibration-transmissibility characteristics.

G W PAINTER, *senior research engineer*
Lord Manufacturing Company, Erie, Penna

Dry-friction damped isolators offer the answer for shielding the equipment in temperature extremes or in presence of contaminants such as fungi, oils, chemicals or dust. Even under simpler operating conditions they may do a better job of damping out vibrations than is possible with the better known viscous-damped isolators. But there are two main limitations to the dry-friction (sometimes called Coulomb-damped) isolators:

- For each of them there exists a critical input amplitude which, if exceeded, gives a runaway resonant conditions.
- Isolation performance tends to be poor when the input amplitudes decrease with an increase of frequency —unless amplitude-sensitive devices are employed.

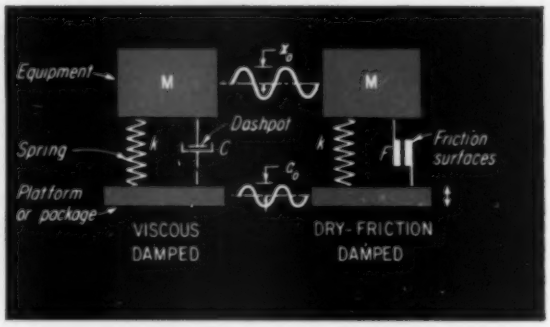
Here are curves comparing performance characteristics of three types of isolators: undamped, viscous-damped and dry-friction damped; equations, developed by the author, which predict the friction force necessary in a dry-friction isolator for best performance; description of a commercial type which includes an amplitude-sensitive device; and an example showing how to use the equations.

VISCOUS-DAMPING

Basically composed of spring and liquid dashpot, the viscous-damped isolator sketched above derives its name from the assumption that its dashpot opposes the motion of the mass when induced into motion with a force c, which is proportional to the velocity across it—a typical characteristic of a mass sliding on a viscous fluid. If a_v is amplitude of induced vibrations and x_o is resulting amplitude of the mass, then the transmissibility ratio, x_o/a_v, is determined by:

$$\frac{x_o}{a_v} = \sqrt{\frac{(c\omega)^2 + k^2}{(k - M\omega^2)^2 + (c\omega)^2}} \qquad (1)$$

This equation is plotted in Curve A to show how damping reduces the transmissibility ratio at resonant frequency (approximately 19 cps in this case) but, unfortunately, increases the ratio at higher frequencies. Specifically, with zero damping, the resonance magnification is infinite while at 25% critical damping it is slightly in excess of 2 (a ratio of 1 means that vibrations to the mass were neither damped nor amplified). For either value of damping, the transmissibility falls below unity for ratios of exciting frequency to natural frequency (ω/ω_n) greater than $\sqrt{2}$. Eq (1) reveals that transmissibility is entirely independent of amplitude of the input vibration. This is characteristic of systems with a linear systems.



Viscous and dry-friction . . .
damped vibration isolators. Both systems involve a mass M mounted on a vibrating platform.

Symbols

a_v = amplitude of induced vibrations, in.
A_a = input acceleration in g's
c = damping factor, lb-sec/in.
c_c = critical damping factor, lb-sec/in.
F = friction force, lb
k = spring rate, lb/in.
M = mass of equipment or machine, lb-sec/in.
P_o = exciting force acting directly on the mass, lb
T = transmissibility ratio, x_o/a_v
W = supported weight, lb ($W = M/g$)
ω = exciting frequency, radians/sec
ω_n = natural frequency, radians/sec
x_o = resulting amplitude of mass, in.

DRY-FRICTION DAMPING

The isolator here has a linear load spring, but with a "dry-friction" damper which provides a friction

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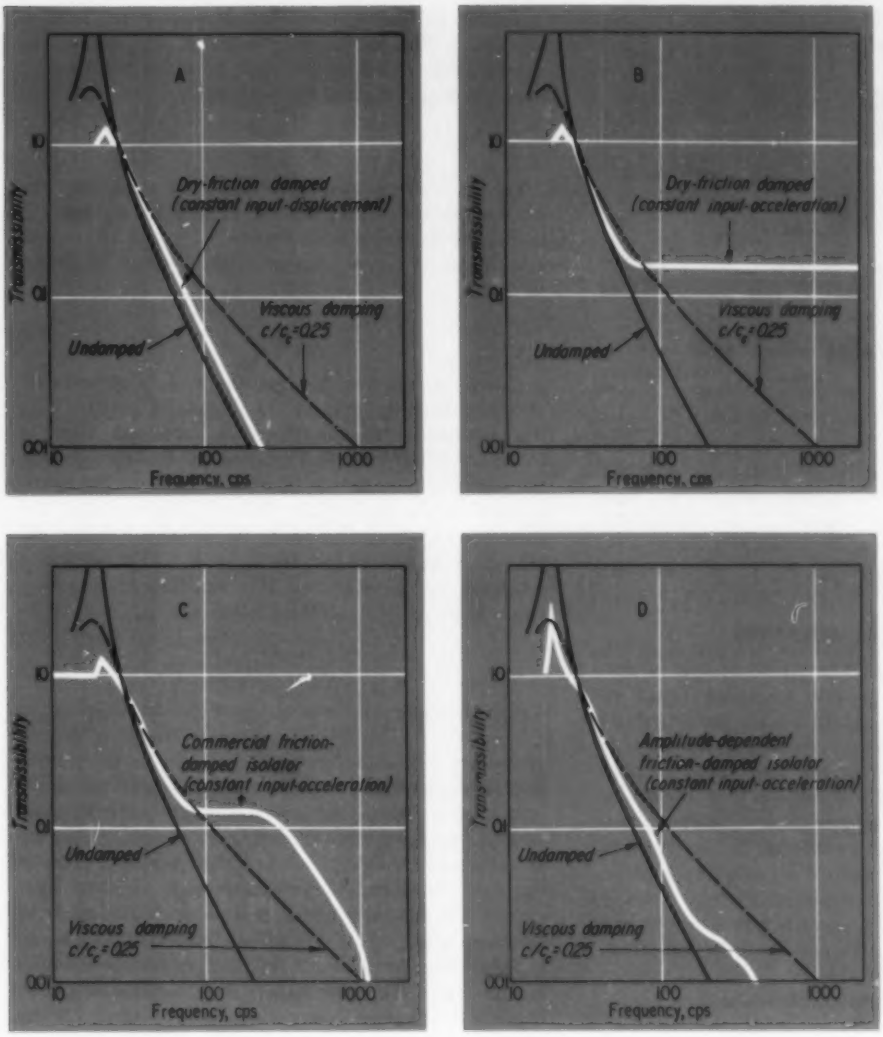
Transmissibility Curves of Isolators With Different Damping Characteristics



force F, whose magnitude is constant at all times, and independent of relative amplitude.

For a constant input-displacement amplitude with changing frequency, the dry-friction isolator dampens vibration much better than the viscous damped type, (Curve A). This is because the viscous-damping force acting on the suspended mass increases in direct proportion to the exciting frequency; with dry-friction method the damping force remains constant.

In practice, however, the input-displacement amplitude present at resonant frequency is usually far more than that occurring in the isolation region. Thus constancy of the damping force can be a disadvantage. As will be shown later, the transmissibility provided by dry-friction isolators is largely controlled by the factor Z, which is the ratio F/ka_n. When $Z > \pi/4$, the resonance magnification is finite; it is infinite for $Z < \pi/4$; $(\pi/4 = 0.785)$. Because large variations of F are usually encountered, the nominal value of Z should therefore not be less than 0.9.

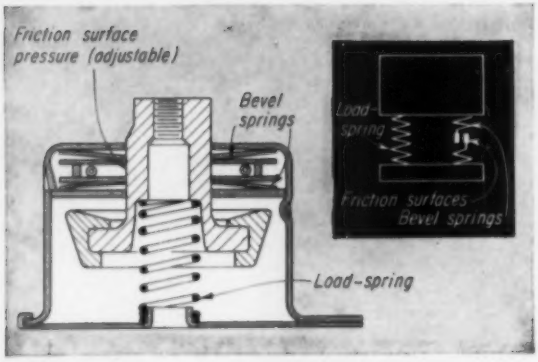
CRITICAL AMPLITUDES

At frequencies well beyond resonance, a dry-friction isolator provides virtually constant transmissibility, Curve B, if the acceleration of the input vibration is constant. This transmissibility value is:

$$T = \frac{4F}{\pi W A_a} \qquad (2)$$

where A_a = the value of the input acceleration in g's.

This is a much higher value than obtained with viscous damping. Because the transmissibility at resonance with dry friction is considerably less than obtained with viscous-damped isolator, it may seem unfair to compare their transmissibilities in the isolation region. However, a reduction of only 14% in the Z factor would result in



Commercial isolator . . .
with amplitude-dependent damping system. Bevel spring is part of damping assembly and is in series with friction surfaces (schematic at right).

an infinite resonance magnification. For every such isolator there exists a critical input amplitude which if exceeded will give an infinite resonance condition. This critical amplitude, a_c is given by:

$$a_c = \frac{4F}{\pi k} \tag{3}$$

COMMERCIAL ISOLATORS

In practice, even the rather primitive designs of dry-friction damped isolators provide somewhat better vibration isolation than the idealized type, particularly at higher frequencies. Although a transmissibility plateau is in evidence in the curve of the commercial friction-damped isolator, Curve C, a frequency is eventually reached beyond which the transmissibility decreases. This behavior results from the flexibility of the structure in series with the friction damper. With constant acceleration, the input displacement amplitude changes inversely as the square of frequency: A point is eventually reached where the damper ceases to slide and the deflection occurs across the "spring" in series with it.

More sophisticated designs employ "amplitude-sensitive damping." This is usually achieved, see illustration above, by incorporating a nonlinear spring (bevel spring in this case) in series with the damper assembly. This avoids the transmissibility plateau effect entirely (Curve D); however, the resonance magnification is seen to be greater than that obtained with the isolators described previously. Amplitude-sensitive damping also avoids harmonics occurring at frequencies which are odd-integer multiples of the exciting frequency and which can excite resonances at frequencies much higher than the apparent exciting frequency.

TRANSMISSIBILITY EQUATIONS

The following analysis derives an approximate method for determining the transmissibility for the foundation-excited dry-friction system, illustrated on page 48. A similar approach has been used in dealing with force-excited systems by Den Hartog.

It is well known that in force-excited systems (force acting directly on the mass rather than on the foundation) the resonance magnification becomes infinite when $P_o > \frac{4}{\pi} F$. Foundation-excited systems can be expected, therefore, to have a critical input amplitude which, if exceeded, will lead to an infinite motion of the mass at resonance. This critical amplitude, a_c, was derived by equating the work done per cycle by the external energy source to that dissipated by damping:

$$a_c = \frac{4F}{\pi k} \tag{3}$$

Eq (3) has practical importance: it establishes the input amplitude which if equaled or exceeded will result in an infinite resonance magnification. If design knows max value of a_o to be encountered, then F must be chosen such that

$$\frac{F}{ka_o} > \frac{\pi}{4} \tag{4}$$

Curves obtained with a computer show dependence of transmissibility upon F/ka_o (opposite page). Very low resonance magnifications are obtained even at $F/ka_o = 0.9$. Along that portion of the curve where transmissibility remains at unity, magnitude of the inertia reaction of the mass is less than the friction force and there is no displacement across the isolator. Relative displacement begins when: $M\omega^2 a_o = F$. This breakaway condition can be expressed as a function of frequency ratio. Since $M = k/\omega_n^2$ then, $k\omega^2 a_o = F/\omega_n^2$, and

$$\frac{f}{f_n} = \frac{\omega}{\omega_n} = \sqrt{\frac{F}{ka_o}} \tag{5}$$

As the frequency is increased past breakaway point, a discontinuous relative motion occurs which is out of phase with amplitude. At higher frequencies the relative displacement becomes continuous. This behavior results in an initial dip in the transmissibility curve followed by a rise to slightly above unity for $F/ka_o = 0.9$. No dip was observed for $F/ka_o > 1.4$. Although that portion of the curve between the breakaway point and the right crest of the dip does not lend itself readily to analysis, this area is not of great practical importance if one remembers that, for $F/ka_o > 0.9$, the peak transmissibility is near unity. (In commercially available isolators, resonance magnification considerably greater than 1.0 are often obtained because of flexibility of the structure in series with the dampers.)

AT HIGHER FREQUENCIES

A method will now be derived for predicting the transmissibility at frequencies lying to the right of the above region.

Assuming for the moment that damping is viscous, the following equation is obtained:

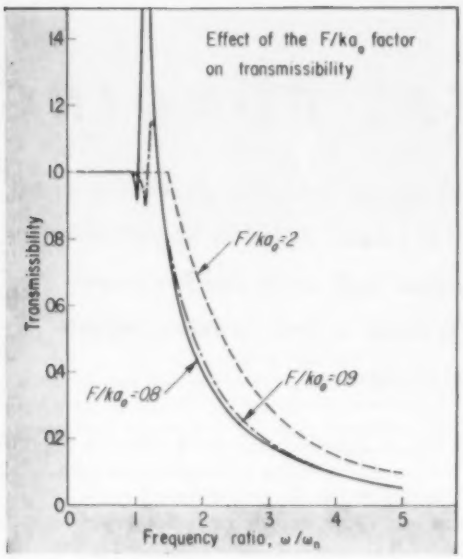
$$M\ddot{\bar{x}} + c\dot{\bar{x}} + k\bar{x} = M\omega^2 a_o \sin \omega t \tag{6}$$

where $\bar{x} = x - a$.

From Eq (6) can be obtained

$$\bar{x}_o = \frac{Ma_o\omega^2\sqrt{1 - \frac{(c\omega\bar{x}_o)^2}{(Ma_o\omega^2)}}}{k\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right]} \tag{7}$$

In Eq (6) amplitude of the damping force is $c\omega\bar{x}_o$. The first harmonic of the friction force can be shown to be $4F/\omega$. Equating this friction-force harmonic



to its viscous equivalent gives:

$$c\omega = 4F/\pi\bar{x}_o$$

Substituting for $c\omega$ in Eq (7) gives:

$$\bar{x}_o = \frac{a_o\left(\frac{\omega}{\omega_n}\right)^2\sqrt{1-\left[\frac{4F}{\pi k a_o}\left(\frac{\omega_n}{\omega}\right)^2\right]^2}}{1-\left(\frac{\omega}{\omega_n}\right)^2} \qquad (8)$$

Acceleration of the mass is dependent upon the forces exerted by the elastic and damping components of the isolator. As it can be assumed that the displacement across the isolator is essentially simple harmonic, the spring force can be considered as sinusoidal with an amplitude $k\bar{x}_o$ and the effective damping force as sinusoidal with an amplitude equal to $4F/\pi$. The damping force is always 90° out of phase with the spring force. Therefore this relation holds true approximately:

$$Mx_o\omega^2 = \sqrt{(k\bar{x}_o)^2 + \left(\frac{4F}{\pi}\right)^2} \qquad (9)$$

Letting

$$F/ka_o = Z$$

and substituting the expression for $\bar{x}_o$ from Eq (8) to Eq (9) gives:

$$\frac{x_o}{a_o} = \left(\frac{\omega_n}{\omega}\right)^2\sqrt{\left(\frac{4Z}{\pi}\right)^2 + \frac{\left[1-\left(\frac{4Z}{\pi}\right)^2\left(\frac{\omega_n}{\omega}\right)^4\right]}{\left[\left(\frac{\omega_n}{\omega}\right)^2-1\right]^2}} \qquad (10)$$

Points calculated from Eq (10) were in excellent agreement with the data obtained with an analog computer (and plotted in above curve). This equation shows that the right-hand expression under the radical can be ignored at values of Z larger than 2, resulting in:

$$\frac{x_o}{a_o} = \left(\frac{\omega_n}{\omega}\right)^2\left(\frac{4Z}{\pi}\right) \qquad (11)$$

It can be shown that when input acceleration is held constant with increasing frequency, transmissibility is constant with increasing frequency. Letting the input have a constant acceleration amplitude of $\ddot{a}_o$, with units of in./sec^2, the input-displacement amplitude becomes $\ddot{a}_o/\omega^2$. Substituting this value in place of a_o in Eq (11) gives (approximately):

$$T = \frac{x_o}{a_o} = \frac{4\omega_n^2 F}{\pi k\ddot{a}_o}$$

or,

$$T = \frac{4F}{\pi M\ddot{a}_o} = \frac{4F}{\pi WA_g} \qquad (12)$$

NUMERICAL EXAMPLE

Assume that equipment weighing 40 lb is to be supported at its center of gravity on four isolators. To limit excursion under shock loads, the system is specified to have a natural frequency of 20 cps, and transmissibility below 15 cps does not exceed unity. Specified input is an 0.080-in. double-amplitude displacement which is constant with increasing frequency until an input acceleration of ±10g's is reached. Beyond this, input acceleration is held constant for further increases in frequency.

Problem: Determine spring rate, friction force, and transmissibility at 100 cps of a friction-damped isolator.

Spring rate comes from the well-known relation:

$$k = (2\pi f_n)^2 M = [(2\pi)(20)]^2\left[\frac{40/4}{386}\right] = 410 \text{ lb/in.}$$

Lowest practical limit for Z is about 0.9; therefore: $F = (0.9)\ (410)\ (0.080)/2 = 14.8$ lb. Breakaway frequency is given by Eq 5:

$$f = 20\sqrt{0.9} = 19 \text{ cps.}$$

Transmissibility can therefore be expected to be unity for frequencies below 19 cps.

Transmissibility at 100 cps can be approximated by Eq (2):

$$T = \frac{4F}{WA_g} = \frac{4(14.8)}{\pi(10)(10)} = 0.188$$

If conditions allowed going below 15 cps, say to 13.5 cps, then an amplitude-sensitive isolator could be employed. This would greatly reduce transmissibility at the higher frequencies.

For **REPRINT** of above article, just check E96 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: You can quickly check out a structure's ability to withstand vibrations by exploring the structure with a velocity pickup. Signals from both pickup and vibrator are fed to an oscilloscope. For a graphic story on how to interpret oscilloscope patterns, see "Structural Vibration—Oscilloscope Tells the Story in Pictures," Feb 2 '59, p 53.

Two rather simple methods of test-dropping the product are winning popularity. For details, with curves, equations and sample problems from industry, see "For Rough Handling—These Shock Tests," May 11 '59, p 75. Reprint of this article can be obtained by checking E80 on one of the Reader Service cards.

A new type of shock absorber has a load-absorbing core and restraining girdle made of silicone rubber. This gives a smoothly increasing spring rate plus high energy-absorption ability. For details, see "New Shock Absorbers" May 12 '58.

today's rules for

RUBBER-TO-METAL BONDING

The bonding technique will now join almost any metal to nearly any kind of rubber. Aided by newer adhesives, the method has proven itself in the last five years—and here's a timely report on how to obtain reliable bonds and desired tolerances.

ROLAND FISCH, *director of engineering*
EDWARD AMANN, *assistant chief chemist*
Ohio Rubber Co, Div of The Eagle-Picher Co

Newer adhesives and rubber-compounding techniques are giving Design a freer hand. No longer are brass and brass-plated carbon steel the only metals that can be bonded reliably to rubber. Almost any metal is now bondable to nearly any rubber—natural or synthetic. This allows design to forget obsolete tables showing which combinations will work, and to concentrate on basics that avoid excess cost, poor performance and production delays.

Rubber-metal bonding can be done two ways: The older method, direct vulcanization, needs no adhesives but is limited to brass or brass plate (or a copper-plated metal, but this doesn't give a strong bond). The newer approach also vulcanizes, but bonding comes from one or more coats of adhesive interposed between the rubber and virgin metal. Heat and pressure do the rest—vulcanizing the rubber and curing the adhesive. Such bonding is done simultaneously with molding and produces a stronger union than simply cementing already vulcanized rubber to a metal part.

WHAT BONDS TO WHAT

In the routine class now are natural and reclaimed rubber and most synthetics, including silicones. Polyurethanes and fluorocarbon rubbers are not yet routine. Among the metals, most are routine. Some require special know-how in certain combinations and designs; copper, phosphorous bronzes, and zinc diecastings are examples. Aluminum, plain or anodized, and stainless steels were formerly not recommended for bonding but now seldom present problems if properly cleaned. Sintered powdered-metal parts ordinarily present no problem; the porous kind can be used if truly dry, but if they have absorbed oils or similar materials it may be impossible to clean them sufficiently for good bonding. For best results, the company doing the bonding also does the cleaning—so surfaces will not contaminate in shipment.

Bonding to plated surfaces by the adhesives method is practical, although bright chrome plate or polished plated surfaces may cause trouble. If plated surfaces are needed, always consult first with the firm doing the bonding.

Experience shows that a normal smooth surface is satisfactory for bonding. Neither polishing nor artificial roughening is needed for good adhesion. Such practices as knurling or ribbing may prevent a good bond by creating pockets that trap air or excess adhesive. Special metal treatments, such as chromate conversions, can increase bond strength when needed.

All bonding is done in precision molds, therefore many design rules that apply to die casting and permanent-mold casting also work for bonded rubber-metal parts. Undercuts and re-entrant curves on the draft surface should be avoided; cores and other complexities add to costs; stress-raisers should be avoided; rubber flow must be provided for; part extraction from the mold must be considered.

In rubber molding, however, the rubber is not injected into the closed mold, but goes into the open mold in solid, uncured form. This frees design because preshaped pieces of rubber can be used to help solve flow problems. Also, the rubber can go into the mold in more than one piece.

RUBBER THICKNESS

Very thin rubber sections are avoided in rubber-metal designs just as in molded rubber parts. A good minimum is 0.100 in: the considerable pressure needed may not be distributed when rubber sections are much thinner—in some areas it may be insufficient for a good bond; in others, it may squeeze the rubber away from between the insert and the mold.

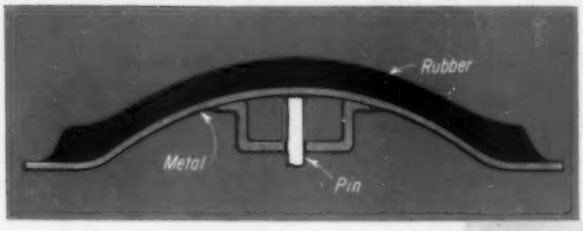
In simple designs, sections up to 2 in. thick usually present no problems. If designs are complex, particularly with variations in sections, it is best to limit thickness to 1 in. Rubber is a poor conductor of heat so outer edges of very thick sections might be over-cured before inner areas are cured sufficiently. Another point against excessive thickness is that hysteresis heat is hard to dissipate. Conversely, a too-thin section may overheat because it is under-size for the expected loading.

To stay inside safe limits, a recommended rule of thumb is: Make rubber thickness four times the amount of expected deflection under load.

METAL INSERTS

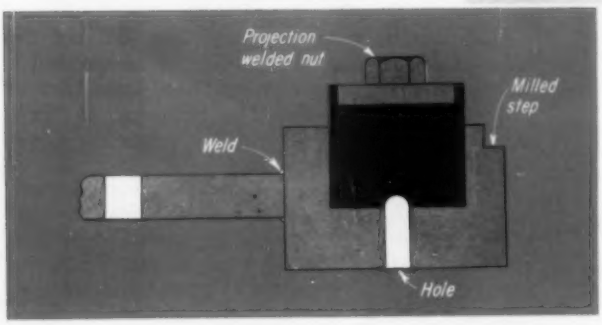
The metal part in the bonded assembly, called the insert, may be a single piece or an assembly of pieces joined by welding or brazing. Soldered assemblies are unsuitable. The solder will be remelted by the bonding temperatures—to vulcanize the elastomer normally needs from 250 to 400 F. A heat-treated insert is satisfactory

3 Ways to Design Better-bonded Assemblies



Support thin inserts . . .
or increase their rigidity. Under bonding pressure this thin stamping would deflect down into attached bracket unless supported with a pin through the hole. Remainder of insert should deflect to get even support from the mold; if not ductile enough to deflect without cracking, self-support is mandatory.

Easy positioning . . .
is key to good design—the insert must locate accurately in the mold and not float during molding. This means that surrounding the insert completely with rubber is impractical. An answer is shown at right. Three holes allow pins to support insert against molding pressures and prevent floating. Center pin aligns insert.



Before mold-bonding . . .
machine or weld the insert to avoid overheating the rubber. Predrilled hole through bottom also avoids burrs which would tear rubber. When needed, threads should be tapped afterward. Alternate is a shallower blind hole that does not extend through the metal.

provided that oxide is removed prior to bonding, and bonding temperatures do not alter the heat-treatment.

Design simplification is often a major reason for rubber-metal bonded assemblies. A rubber mounting block, for example, is bonded to a base plate to eliminate an assembly step or to simplify a complex metal shape designed to mechanically retain the rubber. But design must carefully balance the merits of such simplification against carrying unnecessary metal through the process.

Excess metal may increase difficulty of the bonding operation. For example, it is costly to build a precision mold large enough to contain a large piece of metal just so that rubber can be bonded to a small area. But if a mold is designed so that the metal projects outside, heat may be conducted out too rapidly. It's best to bond the rubber to a smaller metal insert, then fasten this subassembly to the larger part.

TREATMENTS—BEFORE AND AFTER

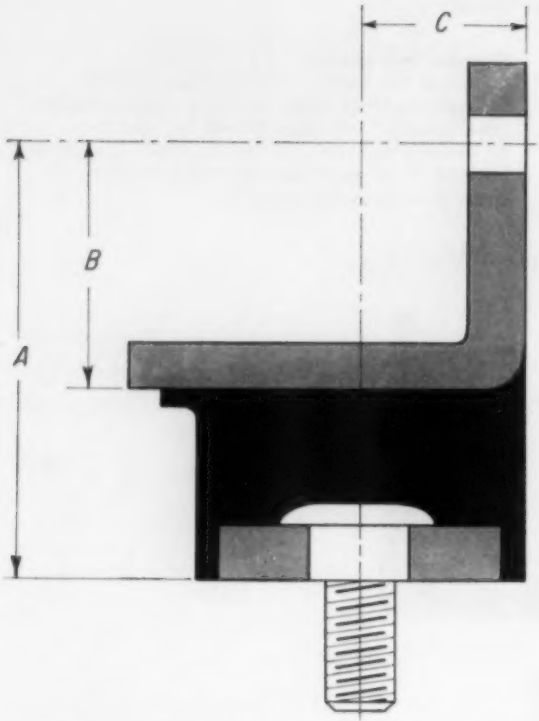
Lacquers, loose-oxide finishes, and highly polished surfaces must be removed or modified, or strong bonds may not result. And the removal method—such as shot-blasting—may adversely affect the insert. For example, holes finish-machined after heat-treating must be protected during shot-blasting. Such extra steps add to cost. So it's better to postpone finish-machining holes until after bonding.

Where post-molding techniques require heat, safe limit is the temperature at which the bond was originally cured. Plating may be done after bonding, provided the bath will not attack the elastomer. Considerable bending is possible after bonding, depending on materials and their geometry.

WHAT ABOUT TOLERANCES?

Rubber and rubber-metal assemblies cannot be held to machining tolerances. Over-all tolerance on a rubber-metal part is accuracy of the insert plus accuracy of the mold, plus shrinkage of the rubber as it cures—for some common elastomers about $\frac{1}{8}$ in./ft in flat designs. Shrinkage cannot be stated in general terms: it depends not only upon factors which can be determined in the laboratory, but on variables which change with each design. Here, however, are basics:

Four classes of precision of molded rubber goods established by RMA—Rubber Manufacturers Association—in-



How dimensions apply . . .

Dimension B (hole center to face of metal insert) has machine tolerances. But molding and shrinkage require wider tolerances for A and C. If parting line parallels centerline of stud, C will be governed by closure tolerances and A by fixed tolerances. Shrinkage in C is less because it is restricted by shear across the metal-to-rubber bonds; in A the rubber is freer to move.

dicate degree of precision that can be expected on over-all dimensions of the rubber components. Class 3 tolerances are considered commercial. Class 4 applies where dimensional control is not critical and is secondary to cost. Class 2 designates high-quality work in general. Class 1 is the tightest, ordinarily applied only to all-rubber components requiring the ultimate in precision.

Dimensions parallel to the mold parting line, known as fixed dimensions, can be held within narrower limits than those normal to the parting line. The latter, called closure dimensions, are affected by flash-thickness variations. Flash thickness, in turn, is affected by nature and mass of the stock, and by mold design. The designer is free to specify one class on all fixed dimensions, and another class on all closure dimensions.

High precision of Classes 1 and 2 usually means higher production cost—closer weight control of stock, fewer cavities per mold, more-costly mold machining, special inspection procedures. Another factor is reduction of flash variation. It is flash-thickness variation, not flash thickness itself, that affects precision. High precision can often be had inexpensively when design specifies "artificial" flash—to be trimmed later. This means deliberate provision for thick flash—$\frac{1}{16}$ in. is common—because it is easier to control thickness variations when flash is thick.

In all cases, though, inserts must be specified within close limits, because tolerances on mold and insert will

RMA Tolerances—Rubber Moldings

(for bonded assemblies, add metal tolerances)

Class	Size (inches)	
	0 to 0.999	1.000 to 1.999
1. Fixed	0.003	0.008
Closure	0.005	0.010
2. Fixed	0.005	0.010
Closure	0.008	0.015
3. Fixed	0.010	0.015
Closure	0.015	0.020
4. Fixed	0.015	0.020
Closure	0.03	0.03

Note—All tolerances plus or minus

be additive. Insert tolerances should be such that outside dimensions will never be oversize, and holes or concavities will never be undersize. This is because the insert must fit in the mold cavity, and plugs, pins, cores must fit into the holes.

FLASH CONTROL

Flash can be minimized, and removed, but the methods add to cost and should not be specified if flash is really not objectionable. Also, some trace of flash will always remain. The technique of "flashless molding" only minimizes flash to such a degree that the remainder is negligible.

If a surface, such as a bearing or seal surface, must have no flash whatsoever the designer should so indicate and be willing to accept flash somewhere else. The mold designer will then avoid locating the parting line at that surface. Otherwise, mold design and molding procedure to minimize flash, or flash removal after bonding (or both) will be used.

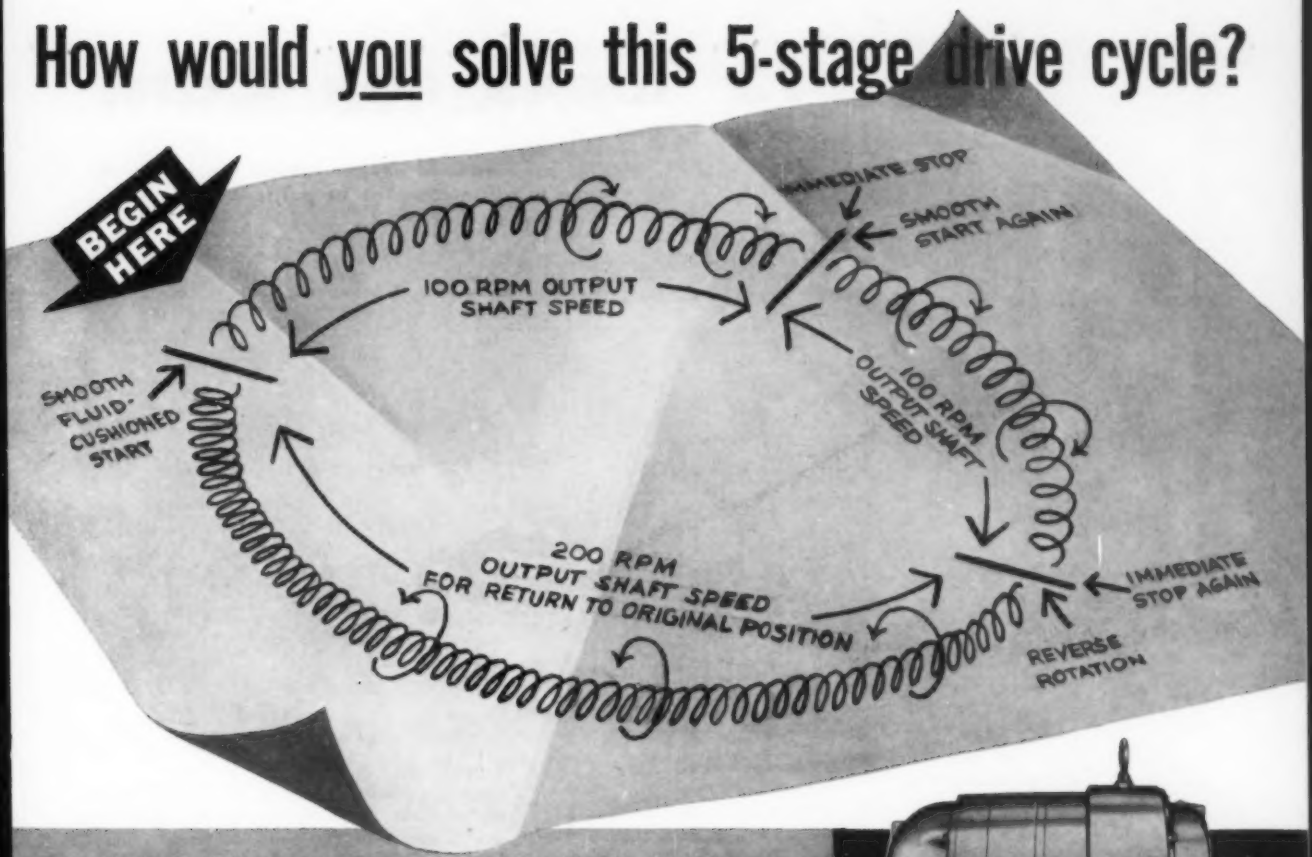
Unless otherwise specified, it is commercial practice to permit flash to remain on metal surfaces if it is tightly adhered. Maximum permissible flash variation, when some special requirements apply, is indicated on designer's prints with the letter T followed by a notation in thousandths of an inch to designate the permissible maximum. For example, T.063 means normal flash of 0.063 in., removable by simple tearing.

Unwanted rubber can also appear on internal surfaces, such as in holes. This can be prevented by plugging the holes, or cleaning them out after bonding. Such extra costs can be avoided by putting the holes where the rubber can't get into them, or eliminating unnecessary holes. A tapped hole in the insert, for example, might better be a bolt projecting down through the metal, with a nut to be used later in assembly.

EDITOR'S NOTE: Other articles to help choose the elastomer for bonding to metal—"High-temperature Butyl," Nov 11 '57, p 90, compares improved butyl with 5 other rubbers for flexibility above 350 F; "Properties and Applications of Silicone Rubber," Mid-Oct '57, p C-22, brings out differences between silicone rubber, natural rubber, GRS and neoprene; "Picking the Plastic for Abrasion Resistance," Mar 31 '58, p 105, lists plastics and elastomers that resist abrasion best.

CIRCLE NO. 55 READER SERVICE CARD→

How would you solve this 5-stage drive cycle?



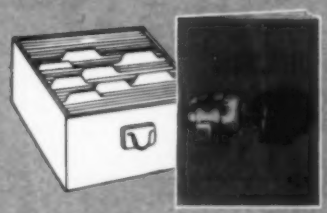
This one modern Reuland power package does all five!

Today's ingenous, automatic machines have demanded a whole new concept in electric motors. No longer will "just any motor do" because the motor now becomes merely an integral part of the modern drive *package*.

Reuland's "Xpandable Design" idea *originated* this modern new approach several years ago. With this unique system, drives incorporating many varied factors are supplied as a single unit . . . *tailored to the needs of each individual customer*.

Modern Reuland Power demonstrates every day that there *is* something new in electric motors. Whether *your* own drive needs are more complicated, or less, than the above sketch . . . it will pay you to take stock and compare with what Reuland can offer.

Our New General Catalog Will Come In Handy — Sent FREE On Request
Gives details on Reuland's "Xpandable Design" . . . also shows how O.E.M.'s save money by using Reuland's free "Special Motor Library." Get a copy for your files now, for sure.



MODERN REULAND POWER

This unit contains an internal fluid coupling . . . a two-speed reversing duty motor . . . gear reducer . . . and magnetic brake mounted between the reducer and the fluid coupling. It is typical of the literally hundreds and hundreds of tailored adaptations available as a result of Reuland's modern "Xpandable Design" idea.

It is easy to see how this one, compact drive package saves costs and space and weight in comparison to installing separate drive units.

MODERN POWER FOR MODERN-DAY PRODUCTS

REULAND MOTORS

REULAND ELECTRIC COMPANY

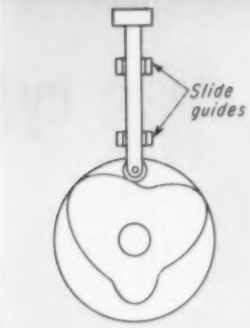
WESTERN DIVISION: Alhambra, California
EASTERN DIVISION: Howell, Michigan
DISTRIBUTORS IN ALL PRINCIPAL CITIES

® REGISTERED TRADEMARK

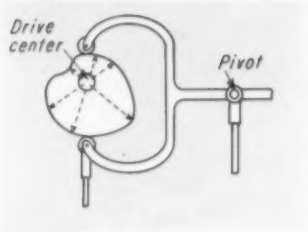
15 IDEAS FOR Cam

This assortment of devices reflects the variety of ways in which cams can be put to work.

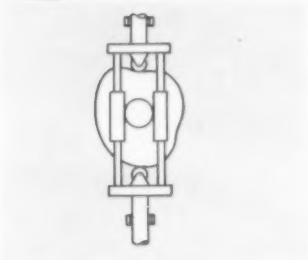
F STRASSER, *Mankowitz & Strasser Ltd, Santiago, Chile*



1

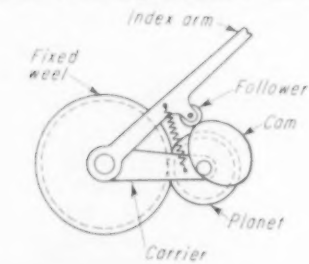


2



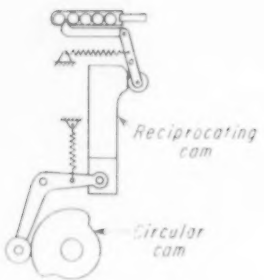
3

Constant-speed rotary . . .
motion is converted (1) into a variable, reciprocating motion; into rocking or vibratory motion of simple forked follower (2); or more robust follower (3), which can provide valve-moving mechanism for steam engines. Vibratory-motion cams must be designed so that their opposite edges are everywhere equidistant when measured through drive-shaft center.



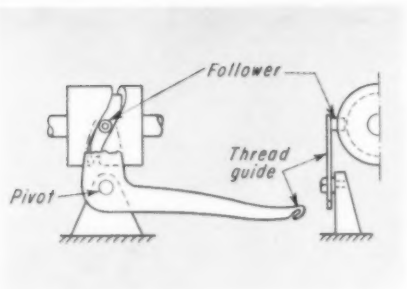
6

Indexing mechanism . . .
combines epicyclic gear and cam. Planetary wheel and cam are fixed relative to one another; the carrier is rotated at uniform speed round the fixed wheel. Index arm has non-uniform motion, with dwell periods.



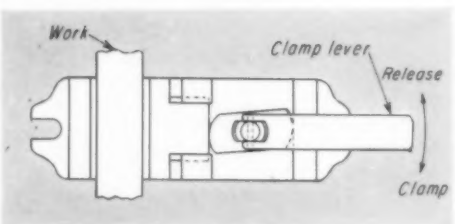
4

Automatic feed . . .
for automatic machines. There are two cams; one with circular motion, the other with reciprocating motion. This combination eliminates the trouble caused by irregularity of feeding and lack of positive control over stock feed.



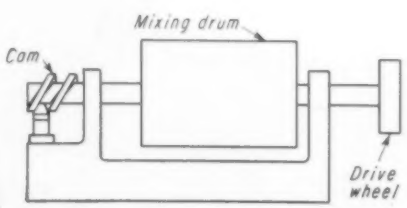
5

Barrel cam . . .
has milled grooves; is used in, for example, sewing machines to guide thread. This type of cam is also used extensively in textile manufacturing machines such as looms and other intricate fabric-making devices.



7

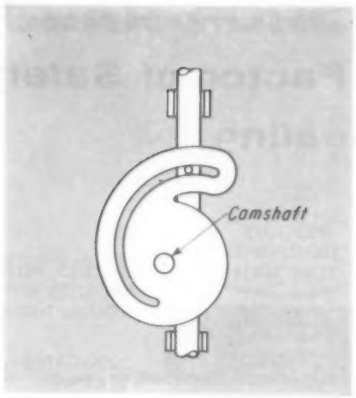
Double eccentric . . .
actuated by a suitable handle, provides powerful clamping action for machine-tool holding fixture.



8

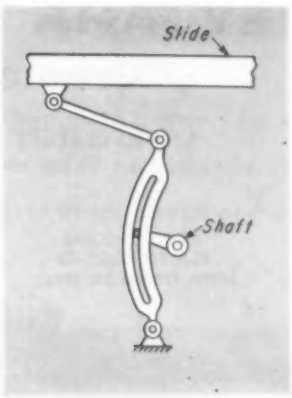
Mixing roller . . .
for paint or candy, etc. Mixing drum has small oscillating motion as well as rotation.

Mechanisms



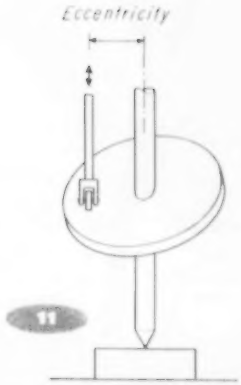
9

Slot cam . . .
converts oscillating motion of camshaft to variable but straight-line motion of rod. According to slot shape, rod motion can be made to suit specific design requirements such as straight-line and logarithmic motion.



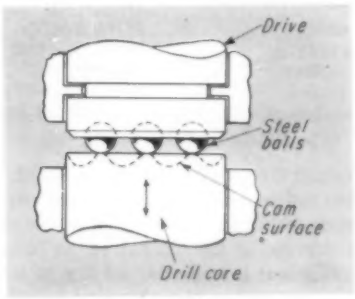
10

Continous rotary motion . . .
of shaft is converted into reciprocating motion of a slide. Device is used on certain types of sewing machines and printing presses.



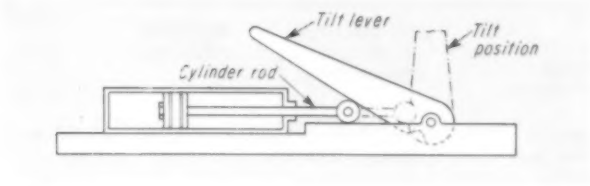
11

Swash-plate cams . . .
are feasible for light loads only, such as in a pump. Eccentricity produces resultant forces that cause excessive loads. Multiple followers may ride on plate, thereby providing smooth pumping action for multipiston pump.



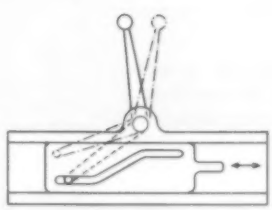
12

Steel-ball cam . . .
converts high-speed rotary motion of, for example, an electric drill into high-frequency vibrations that power the drill core for use as a rotary hammer for masonry, concrete, etc. Attachment can be designed to fit hand drills.



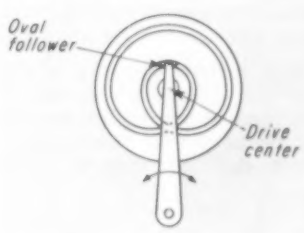
13

Tilting device . . .
can be designed so that lever remains in tilted position when cylinder rod is withdrawn, or can be spring-loaded to return with cylinder rod



14

Sliding cam . . .
finds employment in remote control to shift gears in position that is otherwise inaccessible on machines.



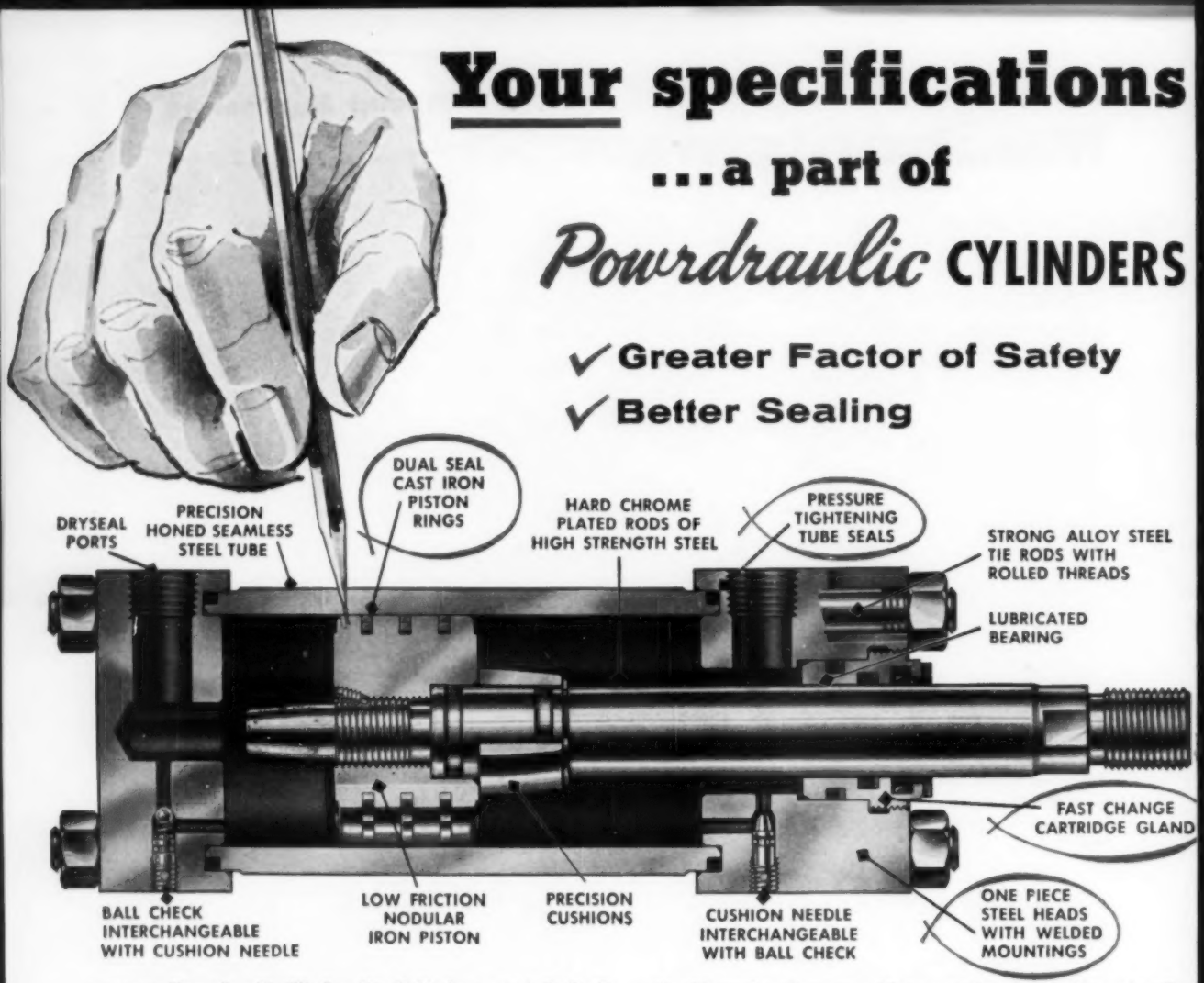
15

Groove and oval . . .
follower provide device that requires two revolutions of cam for one complete follower cycle.

Your specifications ...a part of *Powrdraulic* CYLINDERS

✓ Greater Factor of Safety

✓ Better Sealing


DRYSEAL PORTS
PRECISION HONED SEAMLESS STEEL TUBE
DUAL SEAL CAST IRON PISTON RINGS
HARD CHROME PLATED RODS OF HIGH STRENGTH STEEL
PRESSURE TIGHTENING TUBE SEALS
STRONG ALLOY STEEL TIE RODS WITH ROLLED THREADS
LUBRICATED BEARING
FAST CHANGE CARTRIDGE GLAND
ONE PIECE STEEL HEADS WITH WELDED MOUNTINGS
CUSHION NEEDLE INTERCHANGEABLE WITH BALL CHECK
PRECISION CUSHIONS
LOW FRICTION NODULAR IRON PISTON
BALL CHECK INTERCHANGEABLE WITH CUSHION NEEDLE

HANNA Powrdraulic Hydraulic Cylinders meet J. I. C. recommendations and have industry standard mounting dimensions—2000 psi and 3000 psi non-shock. 1½" through 8" bores.

EXCLUSIVE PRESSURE TIGHTENING TUBE SEALS, located on the outside diameter of the cylinder tube, form a positive seal at all pressures from zero to maximum. Minute expansion of the tube due to pressure increases the tightness of the seal. The "O" ring is fully confined between the head and the tube and will not extrude at high pressures. Unlike other cylinders that seal at the tube ends or inside diameter, the Hanna Powrdraulic Cylinder with pressure tightening O.D. seals will remain tight at all pressures.

DUAL SEAL PISTON RINGS give you twice the sealing power of conventional piston rings. These bi-directional, cast iron rings, consisting of a ring within a ring, seal both the "in" stroke and the "out" stroke of the cylinder. The piston with dual seal rings is packed for life and never should need replacement. You may also choose the optional piston with "U" type synthetic packings.

FAST CHANGE CARTRIDGE GLAND equipped with a leak proof, low friction rod seal forms a tight seal from zero to maximum pressure. Built in rod wiper removes dirt and particles from piston rod as the rod moves "in" and serves as another hydraulic seal to wipe the rod dry on the "out" stroke. You can select either the standard gland or the optional, multiple lip, spring loaded seal. The optional gland is interchangeable and is available with synthetic rubber or Teflon* Vee packing.

ONE PIECE STEEL HEADS WITH WELDED MOUNTINGS are much stronger than conventional bolted construction and assure squareness of mountings. All mountings are designed to carry maximum cylinder loads with a generous safety margin.

Write for Catalog 900 and the name of your nearest representative.

*DuPont's registered trademark.

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CIRCLE NO. 58 READER SERVICE CARD

3 nomographs aid . . .

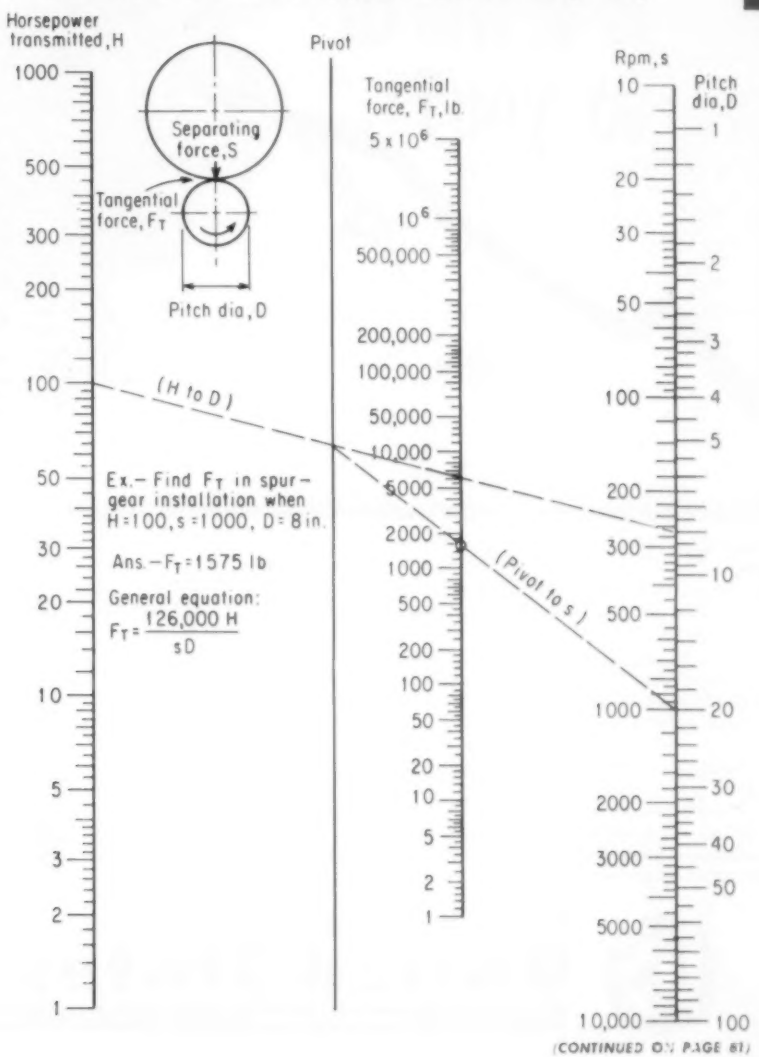
GEAR-FORCE ANALYSIS

They chart quick answers for spur and helical gears. Another set of nomographs, in the next Design Issue, will cover thrust, radial and overhung loads.

TYLER G HICKS
Mechanical Engineer, Hicksville, N Y

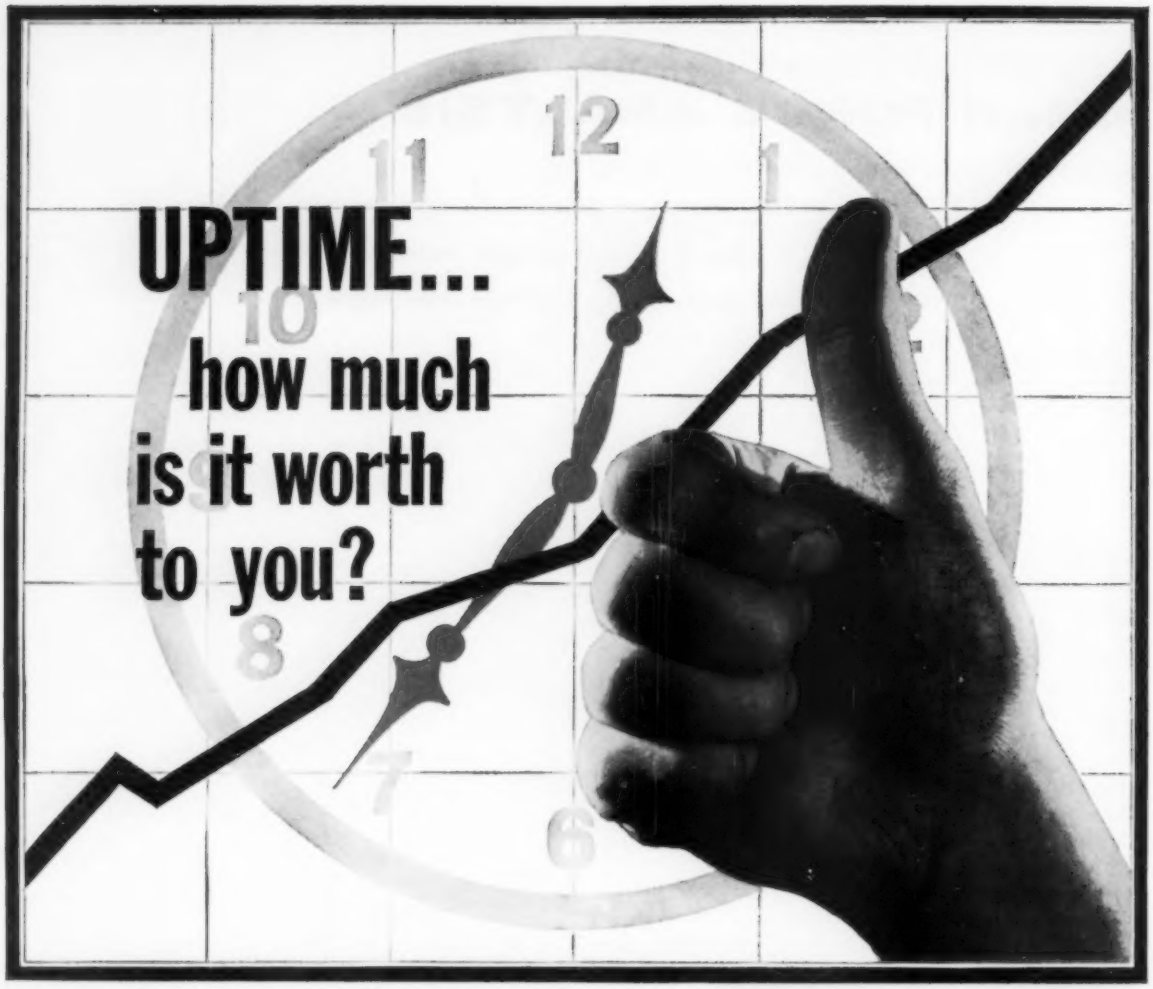
It is important to know what tangential and separating forces result from gear torque. These forces must be known before bearing- and shaft-load problems can be fully answered. The chart on this page gives tangential forces for either spur or helical gears; the two charts on the continuing page give separating forces. In all charts the appropriate secant through any two known quantities yields the unknown third.

1 TANGENTIAL FORCE (spur and helical gears)



(CONTINUED ON PAGE 61)

US RUBBER PACKING



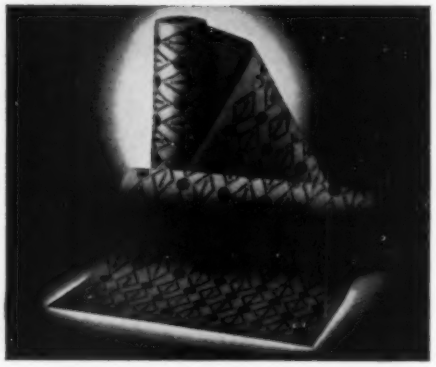
These days, everyone talks about *downtime costs*. Few consider how much *uptime is worth*—the great majority of time when production runs smoothly. How much is uptime worth to *you*, each hour? $100—$200—$300?

And how much are you willing to spend each hour for a packing that will help keep your pumps and flow lines maintenance free? 1¢—2¢—5¢?

That's the kind of money involved when you use a packing like U. S. Rainbow®—first in red sheet packing. Each extra hour of production uptime means hundreds of dollars in production, yet those same extra hours of packing uptime can be had for just pennies... the difference in cost between a quality packing like U. S. Rainbow and ordinary packings.

Rainbow is designed to pack flanges or other parallel surfaces against hot or cold water, air, saturated steam (up to 150 lbs.) and many other hydraulic conditions—and to pack them for longer hours of *uptime*.

When you think of rubber, think of your "U. S." Distributor. He's your best on-the-spot source of technical aid, quick delivery and the finest quality industrial rubber products.



US RUBBER Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

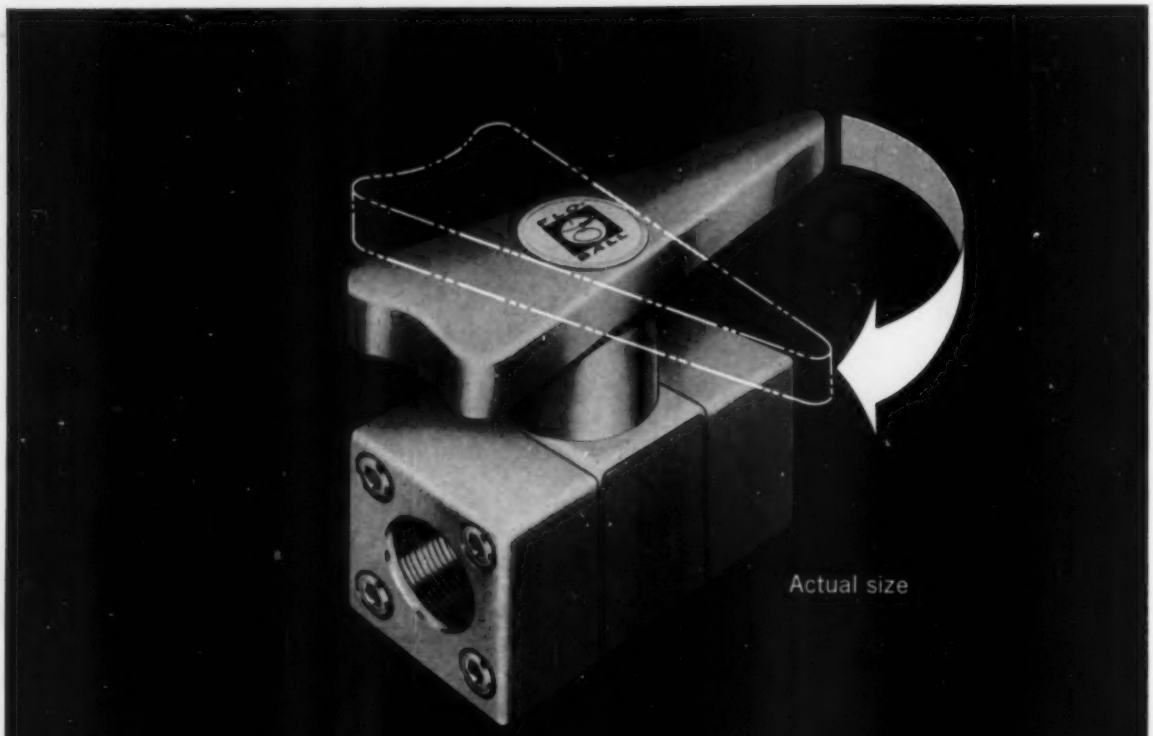
GEAR-FORCE ANALYSIS (CONTINUED)

2 SEPARATING FORCE (spur gears)

Separating force, S, lb
Tangential force, F_T, lb.
Tooth pressure-angle θ
22
20
18
16
14½
12
Ex.— Find S for the previous gear arrangement if tooth pressure-angle is 20°
Ans — S = 575 lb
General equation: S = F_T tan β (F_T acts at 90° to S)

3 SEPARATING FORCE (helical gears)

Separating force, S, lb.
Tangential force, F_T, lb.
Pivot
Tooth pressure angle, β°
Helix angle, α°
Ex.— Find S if F_T = 2000 lb, β = 20° α = 15° Ans.— S = 750 lb.
General equation: S = F_T tan β/cos α
(F_T to β)
(Pivot to α)



Replace obsolete needle valves with the NEW 90° ON-OFF *FLO-BALL*

For 3,000 PSI...

Low torque, instant action . . . a fast 90° turn, requiring just 4 inch-pound torque at 3,000 psi, actuates the valve instantly!

Priced no higher than needle valves!

100% flow efficiency . . . straight-thru ***FLO-BALL*** design has more than twice the flow efficiency of needle valves!

Positive ON-OFF indication . . . large arrow-shaped handle shows valve position at a glance!

Zero leakage . . . Mass Spectrometer tests with Helium prove zero leakage!

Universal mounting . . . can be panel, side, bottom, or line mounted!

Removable flanges . . . damaged flanges can be removed in seconds; no need to replace entire valve!

All stainless steel construction . . . costs no more than old fashioned screw-type valves!

Versatile service . . . ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, and many other fluids.

SERIES 715			
Port Styles and Sizes			
NPT		AND10050	
Size	Part No.	Size	Part No.
⅛	715A1	¼	715A2
¼	715B1	⅜	715B2

Other models are available for service with cryogenic and corrosive media. Also special designs for throttling flow control.

Write today for new catalog describing the world's most complete line of precision valves for industrial and military applications.

FLO-BALL

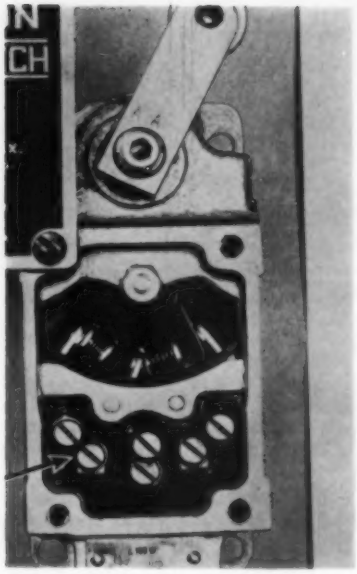
Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX=LIVINGSTON, N. J. 120

SIGNIFICANT COMPONENTS MATERIALS PROCESSES

One-coat white porcelain . . .
enamel for non-premium steels does not require usual blue cobalt ground coat. Such factors as acid and alkali resistance, reflectance, adherence are said to be as high as with two-coat system; thickness is about half, 0.0035 in. Adaptable to most high-production enameling procedures and equipment—only change required is in metal preparation (pickling). **Ferro Corp, 4150 E 56th St, Cleveland 5.**

Circle 300, Reader Service Card



Three-circuit limit switch . . .
can be used to tie together two or three functions without additional relay or to control a motor and simultaneously start or stop a timer or other control. Made in two models: for clockwise operation, with two normally open and one normally closed circuits; counter-clockwise, with two normally open and one normally closed circuits. Both models are readily reversible and use same housing. Units have 70° safety overtravel in both directions, fully isolated circuits and are water-, oil-, and dust-tight, NEMA 12. About $20 per unit; delivery, 7-10 days. **Dept 3P, R B Denison Mfg Co, 102 St Clair Ave, N W, Cleveland 13.**

Circle 301, Reader Service Card

High-pressure, low-flow pump . . .
of centrifugal design is intended to be driven by high speed (15,000 to 100,000 rpm) power sources, and can eliminate need for gear reduction units in some applications. Handles variety of fluids at 2 to 30 gpm; withstands temperatures up to 1000 F. Bearings are lubricated by fluid being pumped. Pressure rise across pump varies from 1000 to 4000 psi, and it can be supplied in 5 to 10 stages depending on pressure requirement. Measures 7⅞ x 3¼ in. dia; weighs 7 lb. $300 to 2500 per unit, depending on performance requirements; delivery, 5-9 wk. **Turbocraft Inc, 492 E Union St, Pasadena, Calif.**

Circle 302, Reader Service Card

Fiber-reinforced gasketing . . .
is composed of a fluorocarbon rubber sheet containing asbestos fibers. Said to resist various lubricants, fuels and hydraulic fluids. Retains dimensions and properties at 500 F in continuous service, to 800 F in intermittent use. 17 x 44 in. sheets are presently supplied on a developmental basis in thicknesses of 0.015, 0.031, 0.062 and 0.125 in. at price of $12-14; immediate delivery in listed thicknesses. **Rogers Corp, Rogers, Conn.**

Circle 303, Reader Service Card

Detector tube measures heat . . .
at infinite number of points over entire length, rather than at a limited number of pre-determined points. Based on temperature-resistance relationship of eutectic salt mixtures, which are packed into Inconel tubing around a nickel wire conductor. When temperature reaches set point at any spot in tube, short circuit is caused between center conductor and outer tube; this, in turn, is sensed by control or alarm system. Tubing can be bent to any configuration and the units available as standard elements can be connected in series to form lengths of several hundred feet. More than one temperature can be detected in the same system. Presently available for detection of temperatures of 225, 310, 400, 575, 765, 900, 1050, 1200 F. Prices average $80 for control unit, $2.75 per ft for detector. Delivery, about 6 wk. **Fenwal Inc, Pleasant St, Ashland, Mass.**

Circle 304, Reader Service Card

. . . CONTINUED ON PAGE 64

Waterproof ribbon switch . . .

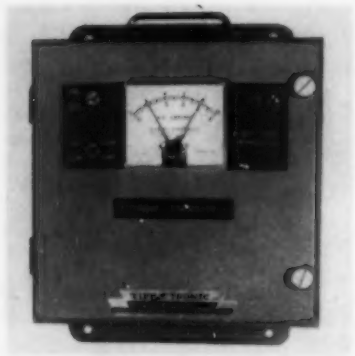
is encased in pure latex jacket and provides a normally open circuit. As little as 8 oz pressure applied anywhere along its length actuates switch, which measures $\frac{7}{16}$ x $\frac{1}{4}$ in. thick. Comes in lengths of 6 in. to 10 ft. Electrical rating is 28 v ac at 1 amp. **Tapeswitch Corp of America, 229-24 Linden Blvd, Cambria Heights 11, NY.**

Circle 305, Reader Service Card

Water-in-oil hydraulic fluid . . .

is fire-resistant and has a viscosity index of 130. Thermal stability is said to be good even when operating for extended periods at 150 F. Suitable for pressures up to 2000 psi. Oil-water ratio of the emulsion is 60:40. **Sun Oil Co, 1608 Walnut St, Philadelphia 3.**

Circle 306, Reader Service Card



Torque control . . .

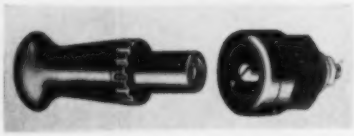
is based on a contact-making ammeter that measures motor current to check torque level. Shuts off power when set point is exceeded. This model, with rating of 10 amp, is intended primarily for use with hand and other power tool installations. Device provides adjustable off-time period for between operating cycles. Can be supplied for inputs of 110, 220 and 440 v. About $271; 3 wk delivery. **Tipptronic Inc, 510 E Washington St, Chagrin Falls, Ohio.**

Circle 307, Reader Service Card

Light-operated switch . . .

is for use with equipment requiring actuation upon changes in ambient light. Designed to turn off at approximately 1 ft-c and back on at 10 ft-c; currently manufactured for tungsten loads up to 150 w on 120 v ac circuits. Measures $1\frac{3}{4}$ in. dia. **Schacht Electric Co, 1213 St Emanuel, Houston 3.**

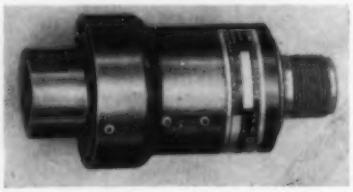
Circle 308, Reader Service Card



Single-conductor plugs . . .

and connectors available in 50 and 100 amp ratings have gold-plated brass pins and sockets in nylon housings that are designed to provide a secure grip. Caps and bodies are molded of same color (six are available) for circuit identification in front and back of panel. Provides solderless connection by means of two socket screws that lock cable in place. **Superior Electric Co, Dept PR, Bristol, Conn.**

Circle 309, Reader Service Card



Pressure switch . . .

is factory-set to actuate at any desired level from 0.5 to 4000 psi. O-ring-sealed aluminum housing is said to be resistant to materials commonly used in pneumatic, hydraulic, lubricating, fuel, pressure and processing systems. Ambient temperature range is —65 to 300 F. Measures 3 x $1\frac{1}{2}$ in.; weighs 4 oz. **Haydon Switch Inc, Waterbury 20, Conn.**

Circle 310, Reader Service Card

Filter for fluid or gas . . .

operates at pressures to 1000 psi and temperatures to 275 F. Designed for use in pneumatic and hydraulic systems, filter can also be used for fuels and other materials. Adapts by changing gasket material. Various types of filtering media can be used, for degrees of filtration ranging from 2 to 25 microns. Depending on pressure range and type of installation, relief valve can be set for 4 to 55 psi pressure differential. **Purolator Products Inc, Rahway, NJ.**

Circle 311, Reader Service Card

Manganese-bronze alloy . . .

for extruded parts such as bushings, gears, cams, shafts, connecting rods and other parts for long-wearing applications is produced entirely from virgin metal and extruded from continuous-cast billets. Supplied from stock in a range of diameters, either in standard mill lengths or cut to specification. **Ampco Metal Inc, 1745 S 38th St, Milwaukee 46.**

Circle 312, Reader Service Card

Current-sensitive fuse . . .

with functional reliability of 99.99% is glass enclosed and hermetically sealed. Guaranteed to meet any specified resistance to atmospheric conditions. Unit is reported to withstand temperatures of —100 to 400 F, vibration of 10 to 500 cps at 15 g max, and shock of 50 g for 11 millisec. Fuse is dimensioned to dissipate heat produced by max rated current under any special blowing time and temperature conditions. Fast, medium or slow blowing fuses are provided. Slow-burning fuses have high time-lag, withstanding heavy surges and instantaneous peaks, but blowing quickly in response to short circuits. Filled with nitrogen or other specified gases. Fuse is companion to temperature-sensitive fuse (*PE—July 6 '59, p 83*). **Networks Electronic Corp, 14806 Oxnard St, Van Nuys, Calif.**

Circle 313, Reader Service Card

30-min. motor-driven timer . . .

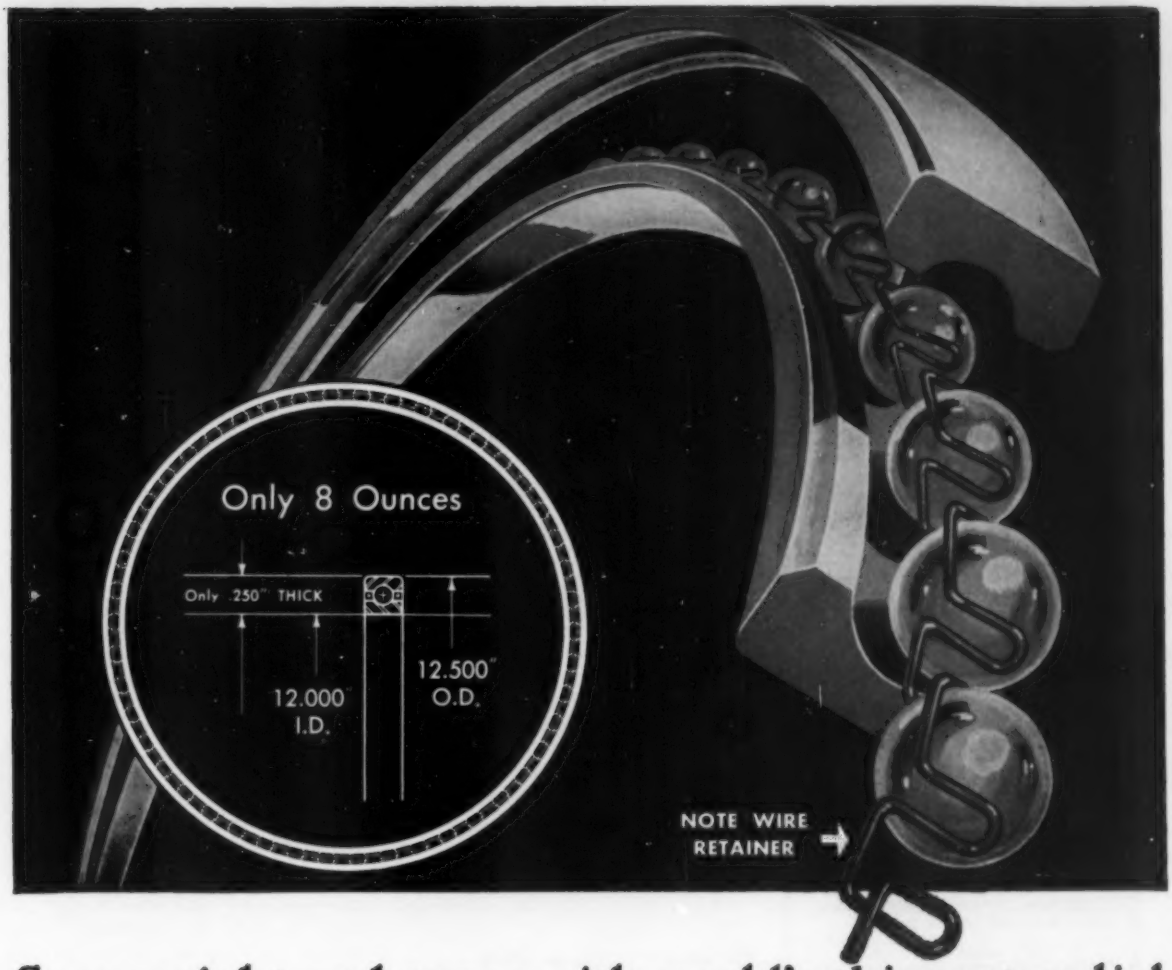
is of synchronous design and is available with one, three or five-minute timing divisions. Desired time interval is set by rotating bronze pointer to point desired on dial. Dial shows full interval and time remaining at all times. In case of power failure, timer automatically returns to starting position for full cycle operation when power is restored. **Cutler-Hammer Inc, 296 N 12th St, Milwaukee.**

Circle 314, Reader Service Card

Numerical display . . .

requires only one input per character, eliminating segment switching devices normally required for this type of readout. Standard model can display 26 letters and

. . . CONTINUED ON PAGE 66



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon ...now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

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K-561R

All types of ball and roller bearings — 4" bore to 178" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings

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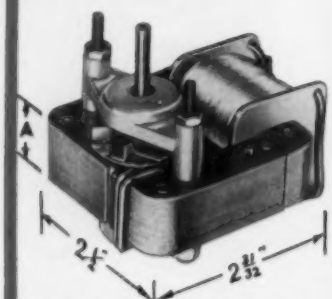
AC MOTORS

1/1500 H.P. to 1/35 H.P.

PERFORMANCE PROVEN . . . . . .

Specify G.I. to be sure! Nearly half a century of experience in solving the motor problems of large and small motor users throughout the world is your guarantee of satisfaction.



MODEL "A" Two-pole, shaded-pole motor. Proved Dependable millions of times over, it's the power choice of the nation's great-name manufacturers . . . setting an amazing performance record in countless applications from phonographs to kitchen fans to pumps.

MODEL	HP 2800 RPM	Locked Torque in./oz.	Max. Torque in./oz.	Free Speed RPM	A
A-3-CW A-3-CCW	1/500	0.7	1.1	3360	3/8"
A-4-CW A-4-CCW	1/350	1.0	1.4	3380	1/2"
A-5-CW A-5-CCW	1/180	1.7	2.7	3430	5/8"
A-6-CW A-6-CCW	1/130	1.9	3.3	3430	3/4"
A-7-CW A-7-CCW	1/100	2.1	3.8	3500	7/8"
A-8-CW A-8-CCW	1/90	2.5	4.5	3480	1"
A-9-CW A-9-CCW	1/70	2.7	5.3	3520	1 1/8"
A-12-CW A-12-CCW	1/60	3.0	6.5	3500	1 1/2"
A-14-CW A-14-CCW	1/50	3.1	7.0	3490	1 3/4"
A-16-CW A-16-CCW	1/45	4.0	7.5	3490	2"

Standard shaft diameter .1817, 1/4" shaft available if desired.

Motors For All Types of Applications

Write today for catalog sheet and quantity-price quotations.

THE GENERAL INDUSTRIES CO.

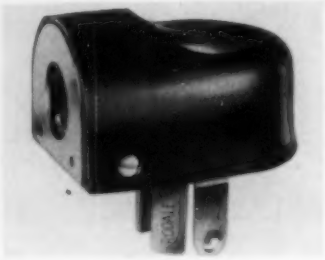
DEPARTMENT GK • ELYRIA, OHIO

10 digits. Neon diode matrix circuit board can be separated physically from display head if required. Input voltage, 230-300 v dc; 165-200 v ac, rms. Display screen size, 1⅜ x 2 in. **Idea Inc, 7900 Pendleton Pike, Indianapolis 26.**

Circle 315, Reader Service Card

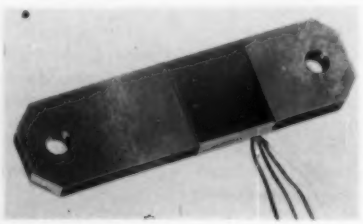
Fluorescent safety paint . . . comes in five color (two shades of orange, red, yellow, green) and two formulations: acrylic lacquer for spraying, alkyd enamel for brushing or spraying. **Switzer Bros Inc, 4732 St Clair Ave, Cleveland 3.**

Circle 316, Reader Service Card



90°-angle electric plug . . . for 30 and 50 amp service is expected to reduce space required for cable and to minimize wear by eliminating sharp angle. L-blade arrangement is available with and without grounding prong. **Rodale Mfg Co, Emmaus, Penna.**

Circle 317, Reader Service Card



Strain multiplier . . . measures minute strains in relatively large structural parts with conventional strain-gage readout equipment. Consists of a metal bar, ends of which are provided with means for fastening to part being tested. Central portion of bar is machined to concentrate and, thereby, multiply strain. Mounted on this area in all stand-

(Continued on page 69)

just off the press...

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Management, designers, engineers--here is ELECTRIC's new guide to help you specify the correct wheels and wheel components for your needs.

Illustrated and detailed are disc wheels, rims, hubs, spindles and other ELECTRIC components for industrial and agricultural units.

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DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY

NEW... adjustable 3/4" Deceleration Valve

Simplifies Cam Design, Cuts Set-up Time, Eliminates Need for Special Valve Spools...

These Features are Important to You:

- Controlled deceleration regardless of flow rate
- Reduces set-up time—eliminates experimenting with cam shapes
- One valve can handle all applications from 5 to 25 gpm giving greater flexibility
- Regulates initial deceleration pressure—eliminates wasted spool movement
- Can be used for applications to 60 gpm without malfunction
- Includes adjustable by-pass needle valve
- Available with or without check for reverse free flow
- Threaded ports or subplate mounting

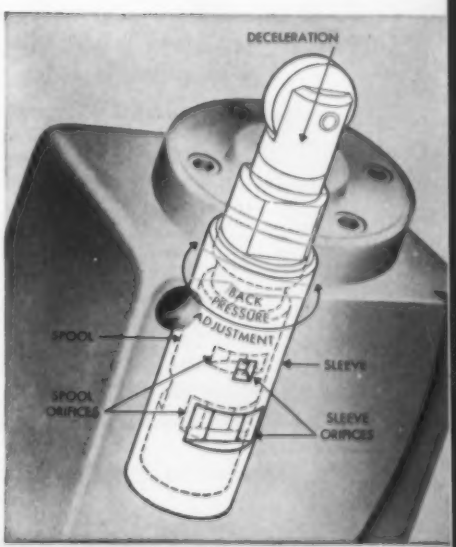
TYPICAL USES:

1. Converting rapid traverse motions to slow, controlled feeds.
2. Rotary indexing operations. Will control deceleration and permit creep to accurate final position.
3. Straight-line transfers. Deceleration control gives smooth stop without excess movement of part being transferred.

Write for installation drawings No. 214322 and 1-214323.

Orifice size (through spool and sleeve) is made larger or smaller by rotation of sleeve. Adjusting screws on the face of the valve rotate the sleeve to the required orifice opening. Deceleration stroke length remains unchanged. No special cam shape is required for valve spool travel.

Patent Pending.



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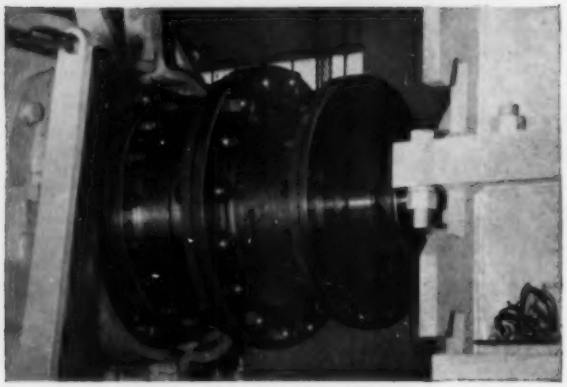
Specials

ARE STANDARD AND VICE-VERSA



In the picture above is a Waldron #8 Cut-Out Coupling. It couples the power to a shearing machine, which takes mild steel strip from coil, straightens it and cuts it to lengths between 3' and 24' at the rate of 1250 feet per minute.

This is a Waldron "special" because it was developed for a particular application. Waldron engineers put a lot of know-how into producing this unit, but with their knowledge acquired through years of experience in dealing with many similar power transmission problems, it became a simple task.

On the other hand, "standard" couplings receive so much attention in production, that they run as if specially designed for the application. Waldron believes that the coupling is as important as the driver and the driven and so should receive the same fine forgings, machining and assembly as the equipment it couples.

If you are in the market for couplings, either specials or standards, speak to the engineers at Waldron. In both cases you will be assured of the highest quality possible.

JOHN **WALDRON** CORPORATION

Subsidiary of Midland-Ross Corporation

NEW BRUNSWICK, NEW JERSEY

MARSH *Mastergauge*

The gauge that has everything!

- **LEAK-PROOF ONE-PIECE CONSTRUCTION** . . . bourdon tube fused to socket and tip by exclusive "Conoweld" process.
- **STURDY "MARSHALLOY" CASE** . . . formed of boiler-plate-thickness steel, copper clad inside and outside to give it the corrosion resistance of solid copper. It's one third lighter, but four times stronger than cast iron.
- **PRECISION "MASTERGAUGE" MOVEMENT** . . . with such exclusive features as the coined sector gear.
- **AVAILABLE WITH STAINLESS TUBE AND SOCKET** . . . choice of stainless steels and alloys for all corrosive conditions.
- **WITH "RECALIBRATOR"** . . . quickest and best way to keep a gauge accurate.

These features are combined only in "Mastergauge", standard bearer for the broad line of Marsh Gauges . . . each the best of its kind. Ask for data.

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CIRCLE 205 ON READER SERVICE CARD

Set Screw Users

Moore offers you a fast, dependable and economical source for one or a million

Moore Set Screws are precision-made and are backed by over 75 years of design-engineering and manufacturing experience. They are of proper hardness for maximum strength and life; they have accurate threads for secure locking action; and they are quality controlled for consistent uniformity. You get fast delivery . . . off the shelf on standard items; two or three-day part shipments on specials.

Improve your product and maintain production schedules with Moore Set Screws. Engineering assistance available.

Moore prices are right . . .
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Condensed Specifications

	Headless Slotted	Square Head	Socket Head
Size (dia.)	#0 to ¾"	#6 to ¾"	#4 to ¾"
Lengths	1/16 to 3"	3/16 to 2½"	1/8 to 1"
Points	cup, oval, round, flat, cone, dog		
Materials	steel, brass, bronze, stainless, aluminum, alloy steel, monel		

Special Heads — milled, slabbed, double slot, knurled.

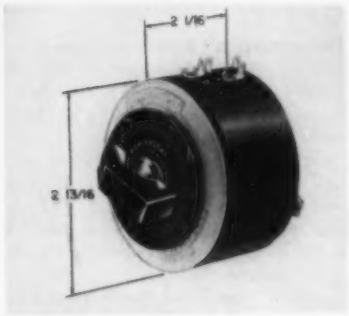
Miniature Headless—#0, #1, #2, #3 sizes in a wide selection of metals, finishes, lengths and points.

MOORE SET SCREWS

George W. Moore, Inc.
since 1880
92 Beaver St., Waltham 54, Mass.

ard models are four strain gages (120 ohm) in Wheatstone bridge circuit, further increasing multiplication factor and causing device to be temperature compensated. One standard model provides multiplication factor of 16; other models provide multiplication factors of 4 to 20. Mounting-hole center distances range from 3 to 8 in. Waldale Research Co Inc, 362 W Colorado Blvd, Pasadena, Calif.

Circle 318, Reader Service Card

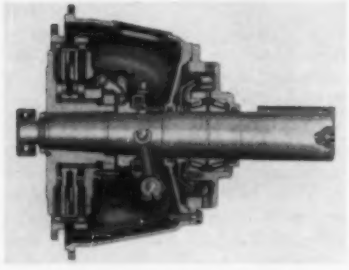


Variable transformer . . . for applications with low wattage requirements operates from 120 v, 60 cps, single-phase input with output of either 0-132 v or 0-120 v, 1.75 amp. Two and three-gang assemblies for higher ratings and three-phase operation are possible. Brushes are metal-backed to reduce breakage, and method of bonding to carbon is said to reduce resistance. Superior Electric Co, Dept 10B, Bristol, Conn.

Circle 319, Reader Service Card

Square-frame dc motor . . . is rated at 3.8 hp at 7200 rpm, continuous duty. Open construction is standard, but explosionproof arrangement is available. Designed to motor specification MIL-M-8609, environment specification MIL-E-5272A. Dimensions: 9¼ x 5 in. dia; weight, 14.4 lb. Hoover Electric Co, Hangar Two, Port Columbus Airport, Columbus 19, Ohio.

Circle 320, Reader Service Card



Ventilated power takeoff . . . is for engines developing either 2500 or 3380 input rpm (depends on material se-

(Continued on page 70)

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FOR 40 YEARS we've built Blue Chip cord sets, tailored to the particular needs of America's top electrical manufacturers. Let CORNISH ***Rugged Individuals*** enhance the performance of your equipment and the prestige of your name . . . despite heat or cold, shock or vibration, ozone or chemical hazards . . . in rubber, neoprene or plastic . . . in decor colors if specified.

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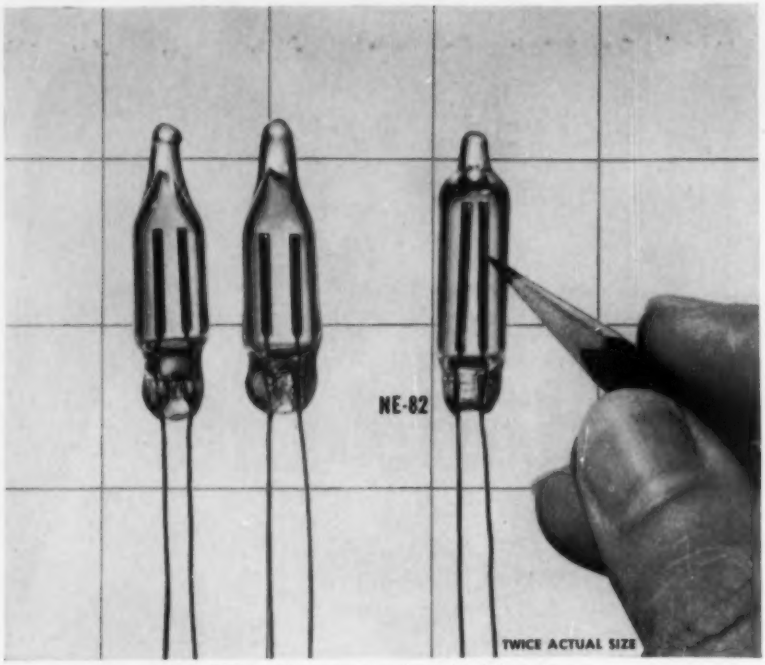

New NE-82 shown with other G-E Glow Lamps

LONGER ELECTRODES on G-E NE-82 Glow Lamp permit up to 5 times higher current loadings

(up to 1.5 m.a.)

The General Electric NE-82 Glow Lamp has controlled characteristics and was specifically engineered for higher current loadings—up to five times higher than most other circuit component glow lamps. Its lengthened electrodes insure a longer period of stable operation at higher loadings than glow lamps having shorter electrodes.

Special techniques developed by General Electric bring the G-E NE-82 to a condition of stability; this helps the NE-82 provide uniform performance within established, predetermined limits. The leads of the G-E NE-82 have been plated for soldering ease. The NE-82 also uses the new "formed tip" construction for minimum over-all length.

DIRECT CURRENT CHARACTERISTICS

Starting Volts	62-78-Volts d-c
Operating Volts (up to 1.5 m.a.)	50-60-Volts d-c
Extinguishing Volts (in series with .25 megohms or more)	50-Volts d-c
Design Current	1.5 m.a.
Life—Change in Starting and Operating Volts at 1.5 m.a.	+5-Volts in 2,000 hours.

Select the General Electric Glow Lamp best suited for your circuit requirements. For further information write for "Glow Lamps as Circuit Components", General Electric Co., Miniature Lamp Dept. M-903, Nela Park, Cleveland 12, O.

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lected for driving ring). Uneven thermal stresses in two-section center plate are minimized by back-to-back diagonal ribs that induce heat-dissipating air flow. Take-off is said to be capable of operating 6 mo between lubrication periods. Uses continuous oil lubrication in bearings rather than grease. Elimination of contact between cam followers and sliding clutch sleeve—except during engagement and disengagement—cuts throw-out collar wear. **Twin Disc Clutch Co, Racine, Wis.**

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provides a 100-pulse output for 360° rotation of shaft whenever its readout head is in magnetic field generated by an arrangement of miniature ferrite toroids and a code track. This non-contacting device is said to be unaffected by wear, dust, humidity, temperature, pressure vibration and other such operating conditions. **Applied Science Corp of Princeton, P O Box 44, Princeton, NJ.**

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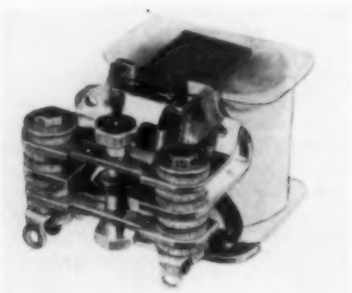

Midget dc relay . . .

is of plate circuit design and has self-wiping 2 amp SPDT contacts. Standard adjustment as for 10 milliwatt. **Kurman Electric Co, 191 Newel St, Brooklyn 22, NY.**

Circle 323, Reader Service Card

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for reproduction of anything from half-size positive intermediates of engineering drawings to enlargements of microfilm positives is not limited to contact printing. Paper can also produce reduced or enlarged copies of positive originals. Standard weight is for document reproduction. Extra-thin weight is for use as reduced-size intermediate of drawings from which final prints are made. Either weight can be used to make enlarged positives from microfilm positives. Both papers are said to have fast exposure times. Special fast-processing wash-off emulsion speeds developing time. Standard weight is supplied in sheet and roll sizes; extra-thin weight is available only in roll sizes. **Eastman Kodak Co, Rochester 4, NY.**

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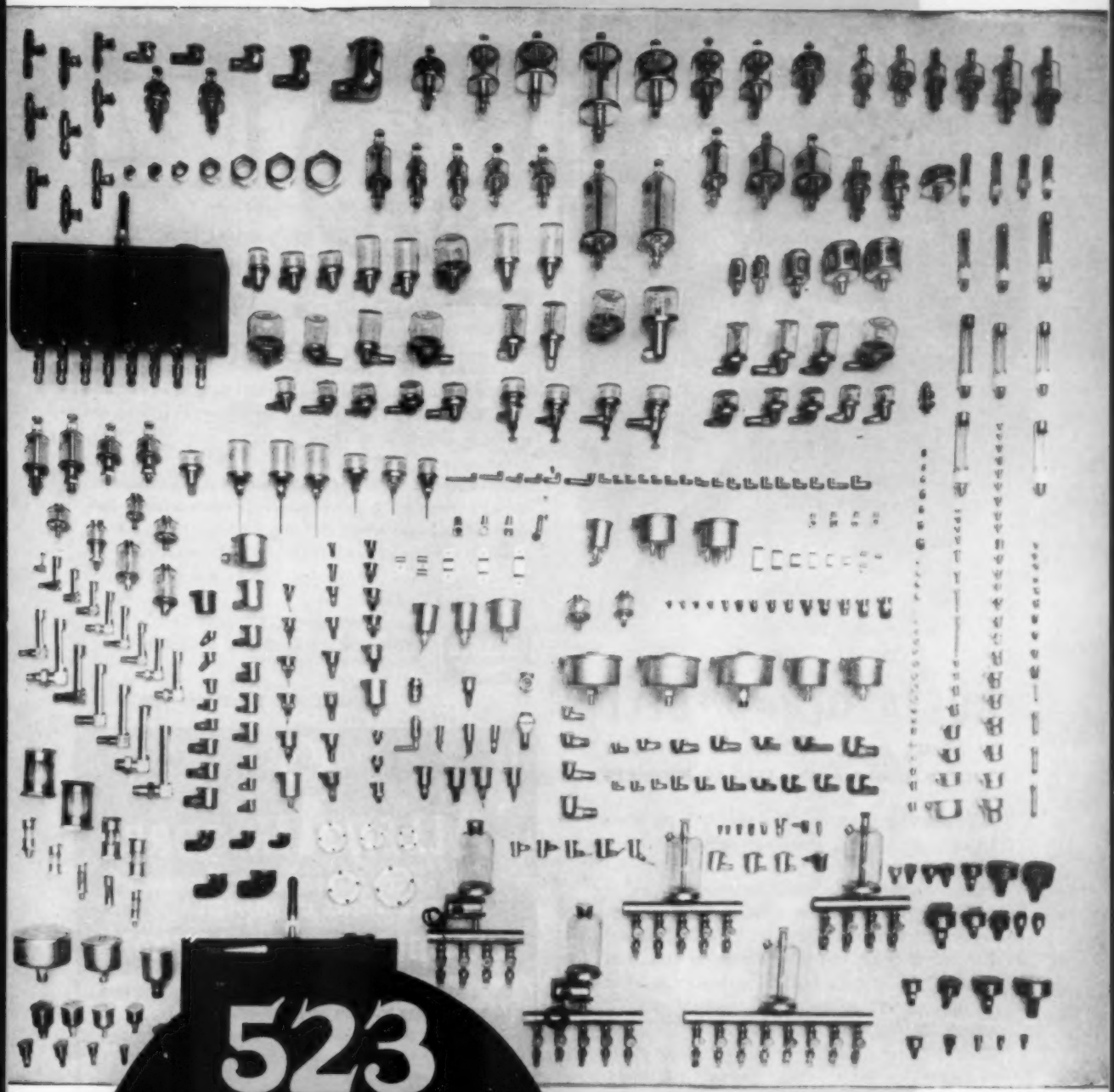

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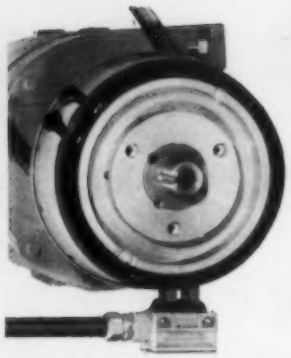

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 79.

ELECTRONIC PARTS AND EQUIPMENT—Industrial catalog, digest, 274 pp. Contains descriptions on variety of electronic parts and equipment for OEM use. Harrison Radio Corp, 225 Greenwich St, New York 7.

Circle 331, Reader Service Card

HIGH-PRESSURE HOSE ASSEMBLIES; WELD-TYPE FLANGE FITTINGS—Supplements to catalogs 101 and 402, 12 and 28 pp. Tabulated specifications and dimensional drawings of high-pressure hose assemblies with pressed-on couplings and flexible weld-type hydraulic fittings. Anchor Coupling Co Inc, E Church & 4th Sts, Libertyville, Ill.

Circle 332, Reader Service Card

LIQUID THERMOSETTING POLYVINYL PLASTICS—Booklet, 16 pp. Describes liquid plastisol plastic together with information on its application and use. Illustrated with fabrication diagrams and examples of applications. Bee Chemical Co, Logo Div, 12933 S Stony Island Ave, Chicago 33.

Circle 333, Reader Service Card

DEEP-GROOVE BEARINGS—Bulletin 110, 12 pp. Information about types and sizes of deep-groove bearings. Dimensions, loads and application data is given for all types. Hoover Ball & Bearing Co, 5400 S State Rd, Ann Arbor, Mich.

Circle 334, Reader Service Card

LINEAR CONVERSION TABLE—Chart. Table converts inches and fractions of inches into decimal parts of a foot. Babcock & Wilcox Co, Tubular Products Div, Beaver Falls, Penna.

Circle 335, Reader Service Card

BREADBOARD PARTS—Catalog 575, 24 pp. Includes descriptions of standard electromechanical breadboard parts, indexed for reference. Components, from grid plates to terminal assemblies, are presented in order they would be used to set up test system. Includes pictures, specifications, outline drawings and ordering instructions. Helipot Div, Beckman Instruments Inc, 2500 Fullerton Road, Fullerton, Calif.

Circle 336, Reader Service Card

BLIND RIVET—Brochure 8-388, 16 pp. Describes conical keystone lock blind rivet for high-strength structural fastening. Includes strength and material specification data, outlines features and presents dimensional information. Photos illustrate typical applications and drawings explain driving cycle. Huck Mfg Co, 2480 Bellevue Ave, Detroit 7.

Circle 337, Reader Service Card

TEST INSTRUMENTS—Catalog ES-8, 24 pp. Lists line of integrated instruments for automatic measurement of sound, vibration and strain. B & K Instruments Inc, 3044 W 106th St, Cleveland 11.

Circle 338, Reader Service Card

SERVO CLAMPS—Catalog 50, 48 pp. Covers line of stock clamps, with specifications, dimensions and outline drawings. Includes tables on comparison of hardness scales, decimal and metric equivalent of fractions, and dimensions and decimal equivalents of twist drills. Sterling Precision Corp, Instrument Div, 17 Matinecock Ave, Port Washington, NY.

Circle 339, Reader Service Card

ROLLER BEARINGS—Catalog PL-559, 16 pp. Information on specifications, applications and availability of nine principal lines of roller bearings. Included, too, is description of manufacturing, research and development, design and testing facilities. Rollway Bearing Co, Syracuse 4, NY.

Circle 340, Reader Service Card

MOTORS AND DRIVES—Bulletin 2650, 8 pp. Summarizes characteristics and modifications for 20 basic types of motors and drives ranging from ¾ to 2000 hp. Louis Allis Co, Milwaukee 1.

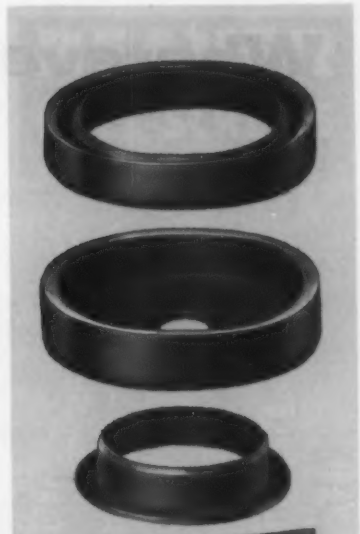
Circle 341, Reader Service Card

MINIATURE POWER CONNECTORS—Series 250 technical catalog, 12 pp. Gives specifications, outline drawings and general information on line of miniature, rectangular power connectors. Electronic Sales Div, DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.

Circle 342, Reader Service Card

HYDRAULIC VALVES AND ACCESSORIES—Catalog 3000, 12 pp. Dimensional and pressure drop charts are included in specification and performance data on filters, check valves, unloading

(Continued on page 75)



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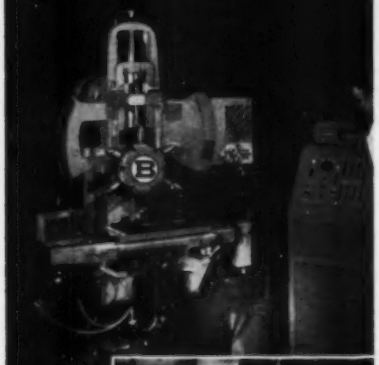

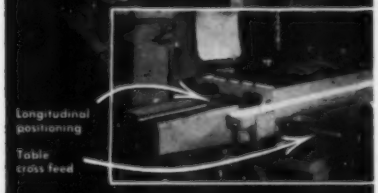

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Catalogs and Bulletins.....continued

valves, relief valves and fuses for hydraulic power systems. Filters shown are rated for pressures to 5000 psi. Valve sections are rated for up to 3000 psi. Waterman Engineering Co, 725 Custer Ave, Evanston, Ill.

Circle 343, Reader Service Card

MEDIUM-PRESSURE HOSE ASSEMBLIES—Technical bulletin 100, 36 pp. General information on flow capacity of hose assemblies at recommended flow velocities, applications and thread sizes is followed by specifications and ratings for medium-pressure hose assemblies, couplings and accessories. Eastman Mfg Co, Manitowoc, Wis.

Circle 344, Reader Service Card

SYNCHRO AND ROTARY COMPONENTS—Catalog, 24 pp. Electric and mechanical characteristics and drawings are given for all types of synchros, size 8 through 22, and similar information is given on line of computing resolvers and linear transformers. Also contains electrical and mechanical information on servomotors and motor generators, sizes 8 through 11. Clifton Precision Products Co Inc, 9014 W Chester Pike, Upper Darby, Penna.

Circle 345, Reader Service Card

FILAMENT-WOUND GLASS FIBER STRUCTURES—Booklet, 8 pp. Describes features, fabrication and physical characteristics of glass fiber structures. Covers facilities for fabricating, testing and research operations. With performance curves and typical structures. Walter Kidde & Co Inc, Belleville 9, NJ.

Circle 346, Reader Service Card

PRECISION POTENTIOMETERS — Catalog, 20 pp. Presents electrical, mechanical and environmental specifications, outline drawings and coil data for production model precision potentiometers, associated turns-counting dials and delay lines. Arranged for comparison of specifications of one series with another. Helipot Div, Beckman Instruments Inc, 2500 Fullerton Rd, Fullerton, Calif.

Circle 347, Reader Service Card

AC SHADED-POLE REVERSIBLE NONGEARED SMALL MOTORS—Catalog R-1, 8 pp. Describes four types of motors with performance characteristics, ratings, construction, dimensions and typical applications. Special section discusses electronic control of reversible motor. Barber-Colman Co, Small Motors Div, Rockford, Ill.

Circle 348, Reader Service Card

QUICK-RELEASE FASTENER—Bulletin GEFCO 100, 4 pp. Lists dimensions,

(Continued on page 77)

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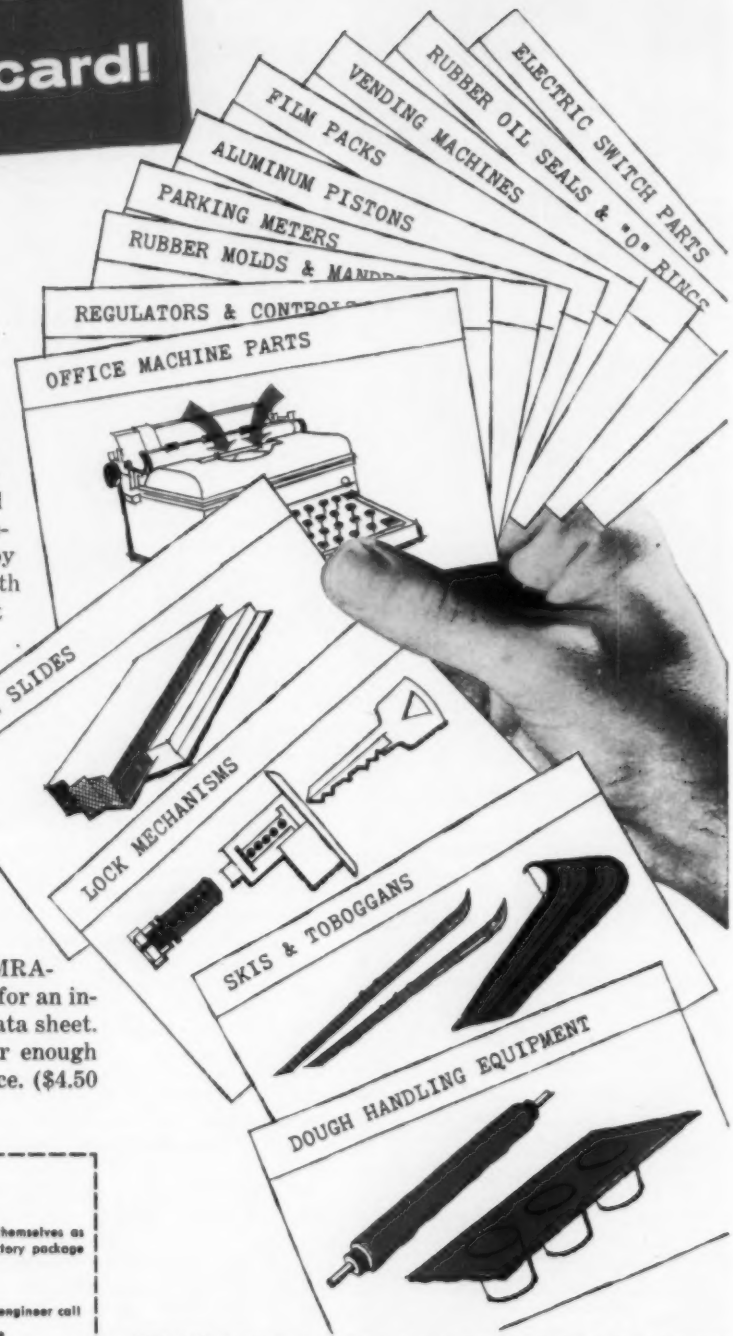

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VARIABLE-SPEED DRIVES–Bulletin 195, 8 pp. Information on hp, duty, speed variation, mounting styles, enclosures and electrical characteristics of drives. Cutaway shows operating mechanisms, including positive pulleys. With photos of variety of modifications and basic types of drives available. Sterling Electric Motors Inc, 5401 Telegraph Rd, Los Angeles 22.

Circle 350, Reader Service Card

FLOWMETERS–Catalog, about 20 pp plus price sheets. Combines basic information on flowmeters, flowswitches and manometers and covers material composition, design characteristics, mounting methods and scales available. Also includes performance information. Seico Instrument Div, Eclipse Fuel Engineering Co, Rockford, Ill.

Circle 351, Reader Service Card

SEMICONDUCTORS–Descriptive literature sheets. Covers MS-41 magnetoresistor, HS-51 Halltron, HR-31 Halltron, MC-1 magnetic circuit and TA-11 thermoelectric junction. Each sheet gives basic specifications, examples of applications and charts showing performance characteristics. Ohio Semiconductors Inc, 1035 W 3rd Ave, Columbus 8, Ohio.

Circle 352, Reader Service Card

ADHERING RESISTANCE THERMOMETER ELEMENTS–Catalog T59, 6 pp. Dimensions, ratings and other specifications are tabulated with line drawings of adhering resistance elements for absolute temperature measurement and control. Includes price list, instrumentation techniques, applications, diagrams. Arthur C Ruge Assoc Inc, Hudson, NH.

Circle 353, Reader Service Card

SOCKET HEAD CAP SCREWS–Catalog sheets, 8 pp. Dimensional and bearing information on fasteners with larger head diameters and larger hex sockets. Safety Socket Screw Co. 6501 N Avondale Ave, Chicago 31.

Circle 354, Reader Service Card

TIME AND EVENT RECORDERS–Brochure, 4 pp. Presents full line of modular time and event recorders, including alphanumeric printers and digital readout systems. Tables show large number of standard combinations possible. Incorporated is guide for specifying in-

(Continued on page 79)

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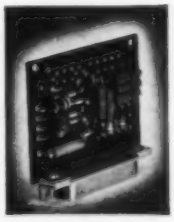

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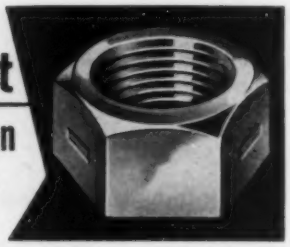

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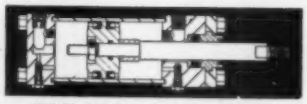

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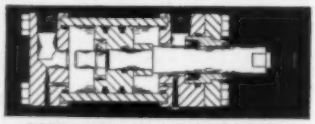

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Circle 355, Reader Service Card

POLYPHASE AND CAPACITOR MOTORS—Bulletins SDA 105 and SDA 145, 4 pp each. Bulletin SDA 105 describes polyphase motors from ½ to 30 hp in frame sizes from 56 to 326U. Bulletin SDA 145 covers ½ to 15 hp capacitor motors in frame sizes from 56 to 286U. Electric Motor Div, Peerless Electric Co, Warren, Ohio.

Circle 356, Reader Service Card

SEALING PIPE THREAD—Bulletin, 4 pp. Discusses how fittings eliminate positioning problems, leakage and overtightening. Describes and illustrates installation. Tru-Seal Div, Flick-Reedy Corp, 7N015 York Rd, Bensenville, Ill.

Circle 357, Reader Service Card

AUTOMATIC CENTRIFUGAL CLUTCHES—Bulletin FM 291A, 4 pp. Describes straight, cam and pin cage types of automatic centrifugal clutches. With motor specifications, torque-speed curves, general application and accessory information. Fairbanks, Morse & Co, Magneto Div, Beloit, Wis.

Circle 358, Reader Service Card

SOCKET SCREW STANDARD—Technical bulletin on 1960 series, 4 pp. Specification and application information for large-diameter-head socket head cap screw. Covers range of standard sizes from No. 0 through 1 in. dia. Seating torques are tabulated to provide recommended tightening values. Chart compares 1936 and new 1960 series. Standard Pressed Steel Co, Dept 545, Jenkintown, Penna.

Circle 359, Reader Service Card

Letterhead Requests Only

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

CONTROLLED TERMINAL BLOCKS—Bulletin, 16 pp. Illustrates and describes applications and specifications of heavy-duty, medium-duty and sectional-type terminal blocks and shows typical list prices for them. Marathon Special Products Corp, Sub of Marathon Electric Mfg Corp, Erie, Penna.

WELDING FITTINGS AND FORGED STEEL FLANGES—24 data folders, FDC 252 through 275, 4 pp each. Catalogs by size, dimensional and physical specifications various individual welding fittings and forged steel flanges. Includes line drawings. Babcock & Wilcox Co, Welding Fittings Dept, Milwaukee 46.

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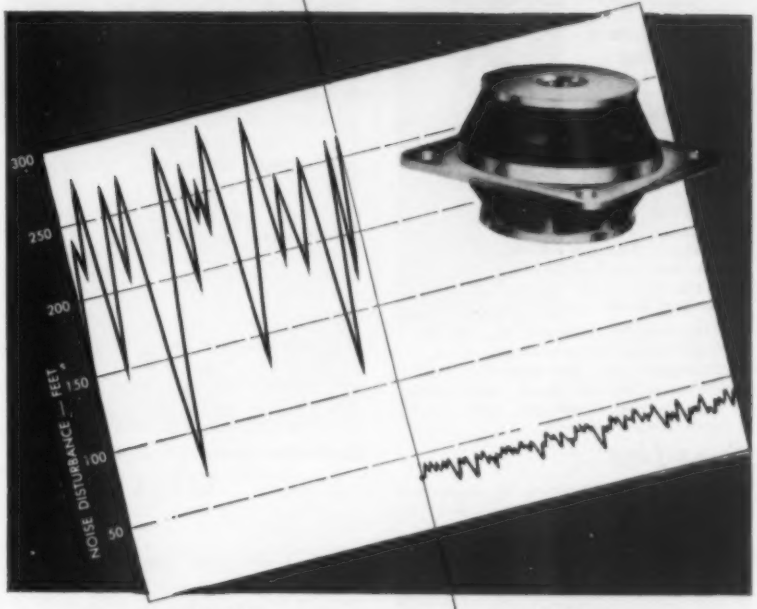

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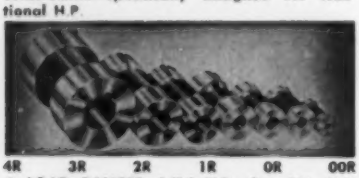

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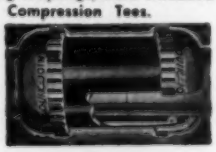

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Michigan City, Indiana

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What variations in performance to expect for components that will pass production tolerances. July 6 Circle E 90

Test Rates Solid Lubricants
How press-fit method works; with list of high-pressure candidates. June 22
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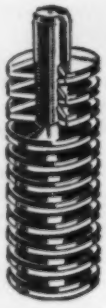
(Continued on page 81)



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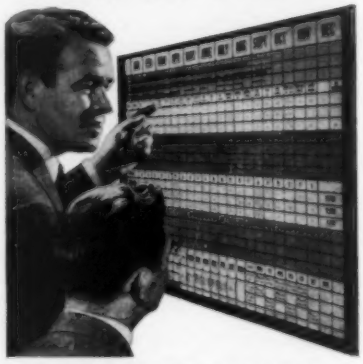

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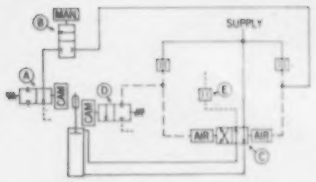

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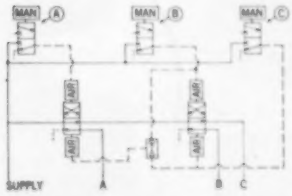

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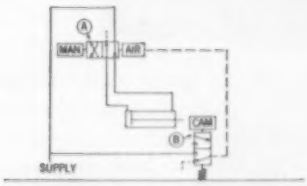

3. AUTOMATIC RESET—To reset the operating valve "A" after completion of an operation. Moving the manual operator admits supply air to the cylinder to extend its rod. At the end of the cylinder rod stroke cam operator valve "B" is actuated to connect supply air to the air pilot operator of valve "A." This returns this valve to its original position. Supply air is then connected to the cylinder to retract the cylinder rod. The circuit is now ready for recycling.

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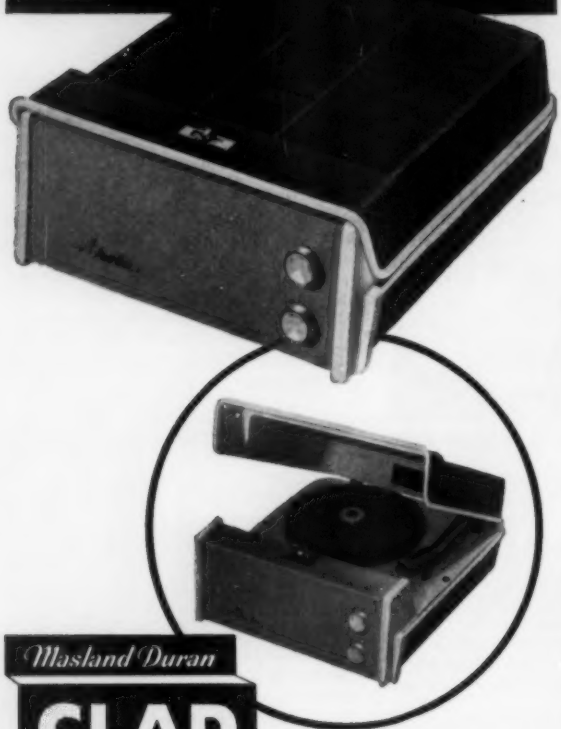

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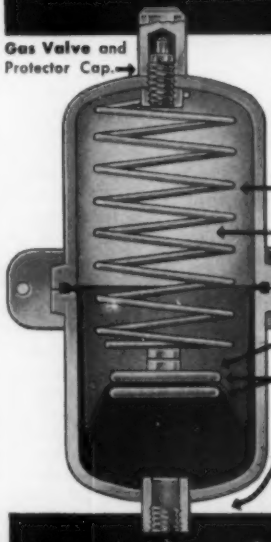

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DESIGN ABSTRACTS

Crack Initiation and Propagation in Aluminum Sheet

Low cycle–high stress fatigue tests in fluctuating tension on transverse and longitudinal specimens of 1100-H-18 aluminum determined at several stress levels the number of cycles required to initiate crack of arbitrary length at root of mild, semicircular notch and then to propagate crack to failure. Fatigue crack growth is shown to consist of short bursts of growth followed by periods of no measurable growth. Cracks in transverse specimens initiated sooner, propagated faster but not as far as those in longitudinal specimens before failure occurred. Explanation based on metallurgical state of material is offered.

"Anisotropy of Crack Initiation and Propagation in Cold-rolled Aluminum Sheet," Lipsitt, Forbes and Baird, Wright Air Development Center. Presented at 62nd Annual Meeting of ASTM, June 21-26, 1916 Race St, Philadelphia 3.

Explosive Metal Forming

Theory and practice of high energy ratio process in which metal shapes are produced by energy obtained from pressure exerted by explosive charges on liquid in closed chambers are discussed. The three basic methods (free forming, bulkhead forming and cylinder forming) are described. Characteristics of explosives used, theory governing size of charge, equipment design, applications, and means of obtaining design details are included.

"Explosive Forming," (Special Report No. 474), sundry authors. American Machinist, June 15 1959, 330 W 42nd St, New York 36.

Steel by Slipstick or Slapstick

While many of the examples for this discussion of the best procedures for selecting steels for manufactured parts are drawn from automobile manufacturing practice, much of it is applicable to other material specifying jobs. A list of eight questions the engineer should ask himself about his steel selection is included.

"Steel by Slipstick or Slapstick", R. E. Harvie, Chevrolet Motor Div, SAE paper 737, Society of Automotive Engineers, 485 Lexington Ave. New York 17.

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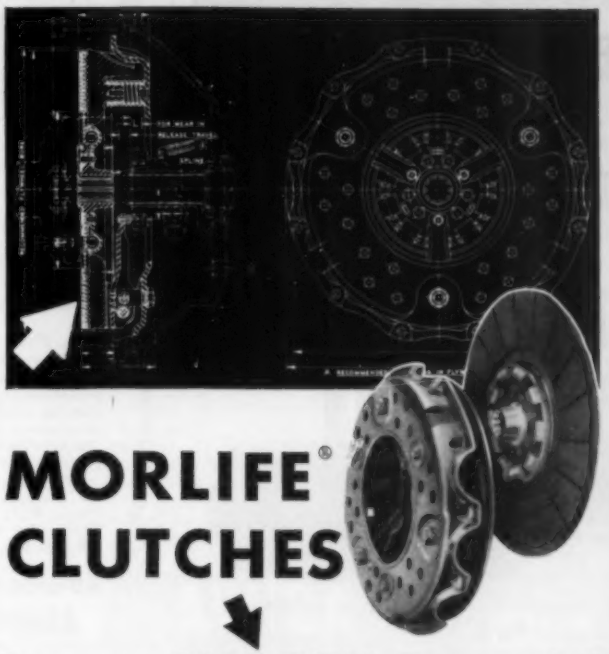

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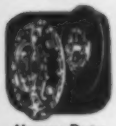
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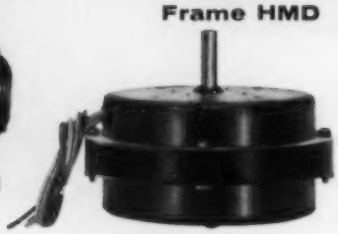

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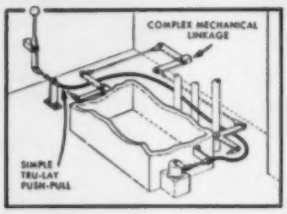

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PB 151463. D W CONOVER, C L KRAFT. (WADC Technical Report 55-471) Office of Technical Services, Dept of Commerce, Washington 25, DC. Paperbound, 8½ x 11, 166pp. 75 cents.

When it is necessary to choose colors that have a specific code meaning, it is important that the colors chosen will not easily be confused with one another. Here are five recommended lists of Munsell colors and a summary of the experiments conducted in arriving at those lists. Which list is chosen will depend on how many coding elements are needed–there are lists for eight, seven, six, five and four coding elements. Included is a full color chart and an extensive bibliography.

Bearing Materials for Elevated Temperatures

APEX 464; J P DENNY, General Electric Co, Cincinnati 15, Ohio. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 38 pp. $1.25.

Promising areas of investigation are specified for the development of bearing materials which will operate in air at elevated temperatures. A discussion of physical and chemical properties of bearing materials and of basic principles to be considered in this development is followed by recommendations.

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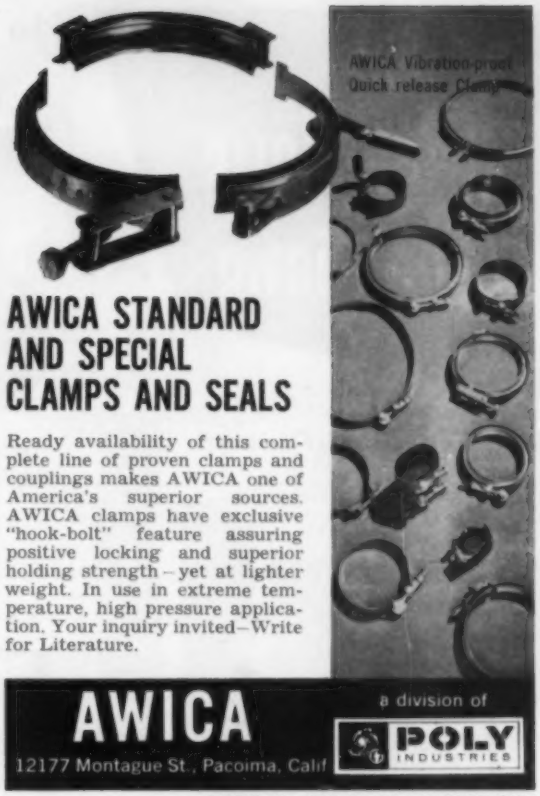
Solid-state Magnetic and Dielectric Devices

HAROLD W KATZ. Published by John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 6 x 9, 542 pp. $13.50.

This textbook begins with classical treatment of magnetization and polarization–the essential electric properties–and later shows general application of these principles to electrochemical phenomena, square loop material, and microwave frequencies. The remaining chapters cover electrostrictive and magnetostrictive systems, nonlinear magnetic and dielectric ma-

(Continued on page 87)



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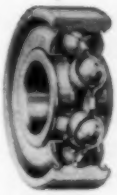

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Heavy-Duty, Cam-Operated

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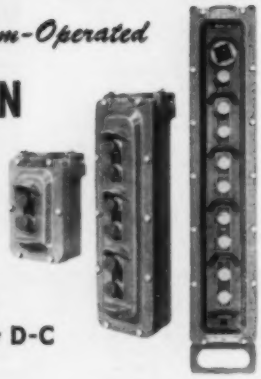

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Fundamentals of Electrical Engineering–2nd Edition

FRED H HUMPHREY. Published by Prentice-Hall Inc, 70 Fifth Ave, New York 11. 6 x 9, 534 pp. $8.50.

Textbook aims at students specializing in fields other than electrical engineering. For this reason, capsule rather than highly theoretical descriptions of working principles are given. The book is up-to-date and includes important topics in electronics and solid-state physics. Subjects included are ac and dc circuits and measurements, ferromagnetism, electromagnetic induction, capacitors, insulators, transformers, motors, generators, rectifiers, feedback control, computers, amplifiers, electron tubes, transistors, thyratrons, transducers, instrumentation, heating, welding, lighting, wiring and even economics. Chapter problems and an index are also included.

Dimensional Control in Precision Manufacturing

J L GADZALA. McGraw-Hill Book Co, 330 W 42nd St, New York 36. 8½ x 6, 203 pp, $7.50.

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(Continued on page 89)

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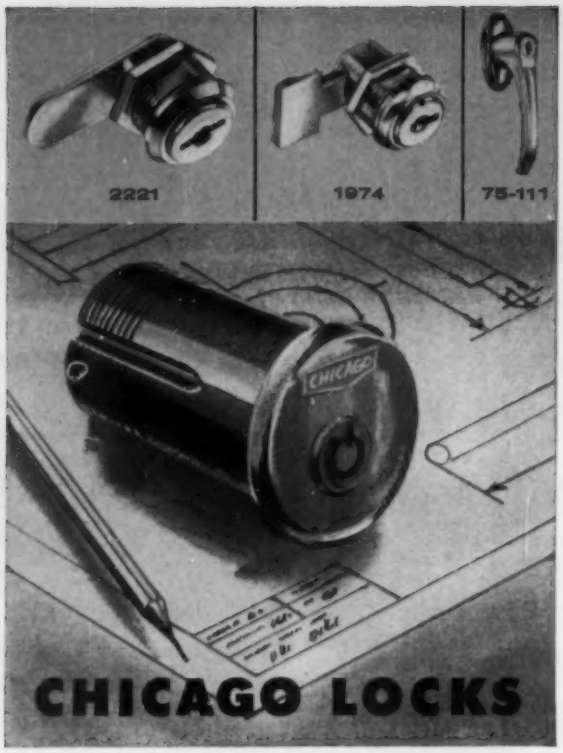

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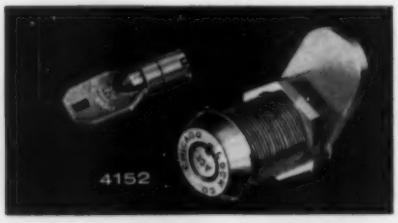

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Other Books of Interest

Solion—Principles of Electrochemistry and Low-power Electrochemical Devices.
PB 131931, Reed, McQuitty, Lane, Hurd. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 46 pp, $1.25.

Selection and Evaluation of Rare or Unusual Metals for Application to Advanced Weapons Systems, Part I—Literature Survey.
PB 151311, Love. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8¼ x 10½, 174 pp, $3.

List of High-purity Metals Available from American Producers, ISC-1029.
ISC-1029. Wilhelm and McCarley. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 56 pp, $1.50.

Analysis of Pipe Structures for Flexibility.
John Gascoyne. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 7½ x 10, 181 pp, $7.50.

Much of this study is concerned with process piping, but some of the data, work examples, codes and standards may be applicable to fluid power systems.

Resilient Cushioning Materials, SCTM 35-59 (12).
L T Wilson. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 130 pp, $2.75.

Primarily concerned with cushioning materials used in packaging for safe transfer of products.

Basic Electricity—Second Edition.
P B Zbar, S Schildkraut. McGraw-Hill Book Co, 330 W 42nd St, New York 36. 8½ x 11, 97 pp. $2.25.

Laboratory manual for radio and television technicians.

Technical Papers, Volume 5.
Society of Plastics Engineers Inc, 65 Prospect St, Stamford, Conn. 8½ x 11, 100 papers.

These are papers presented at the 15th Annual Technical Conference, Jan, 1959.

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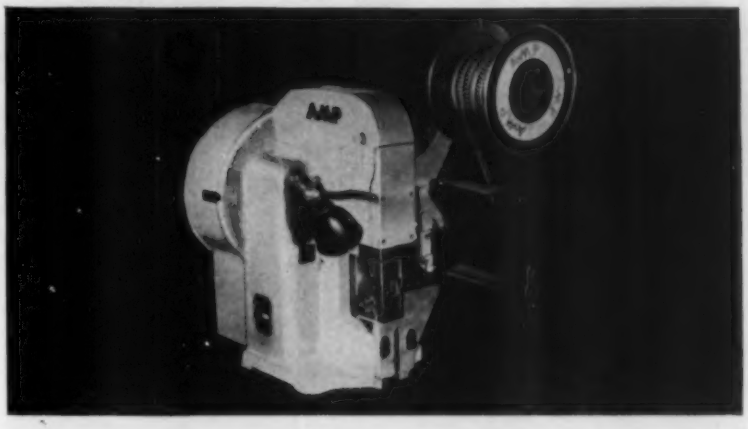

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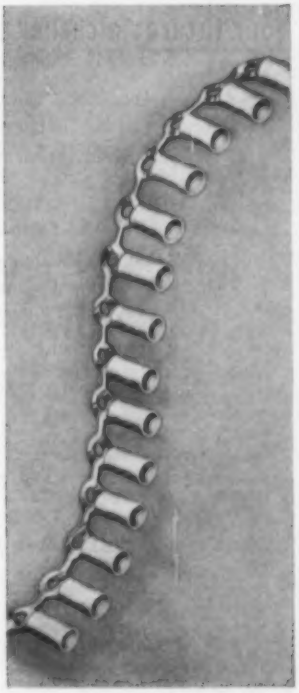

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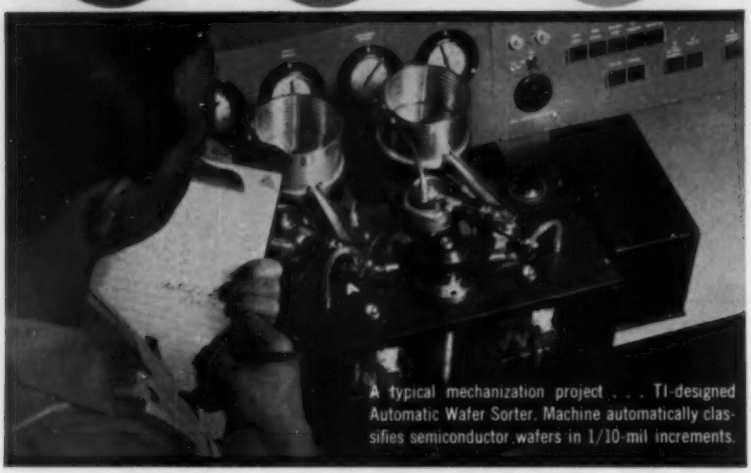

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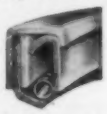
NATIONAL OIL SEAL LOGBOOK

Oil Seal Selector Chart

The data given below indicate, for most common applications, the type of oil seal that will operate best under given conditions. Where one or more parameters are extreme, modified or special seals may be required. For engineering help or availability details, call the nearest National Seal Engineer. Look under Oil Seals, in the Yellow Pages.



50,000 series
Micro-Torc
Leather

450,000 series
Syntech
Synthetic

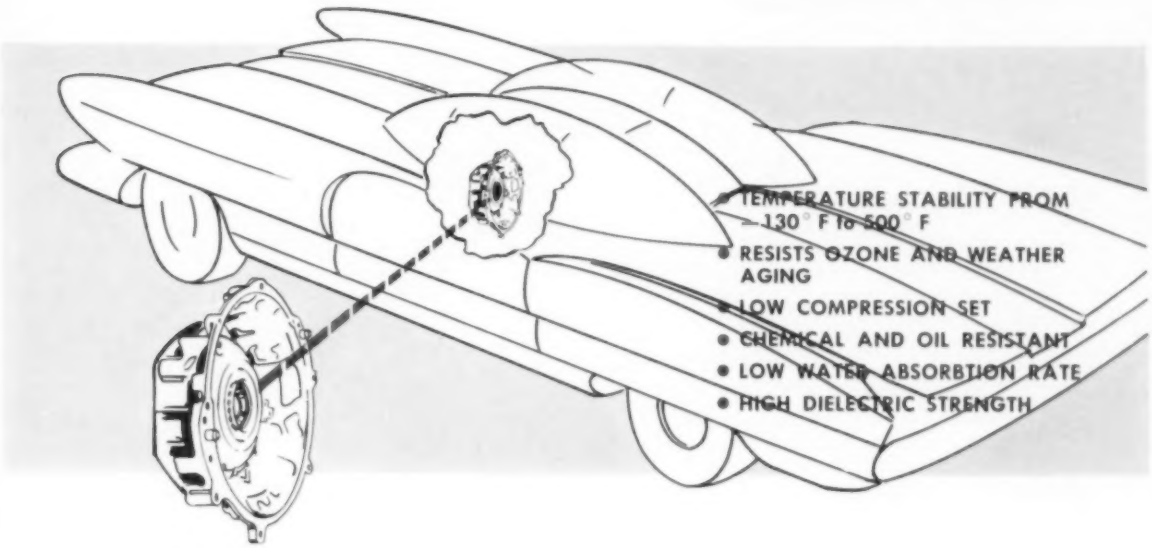
410,000 series
Syntech
Synthetic

MATERIAL SEALED	Mineral base oils and greases are most common materials. Availability of lubricant, criticalness of service, and cleanliness strongly influence construction choice. National Micro-Torc leather seals are recommended for grease and oil applications and particularly where semi-starved lubricant conditions may exist. For oil and fluid "zero leakage" service Syntech seals are normally considered. For applications involving both "zero leakage" and heavy dirt conditions, the user may wish to consider dual lip Syntech seals.			
SHAFT SPEED	Prime factor in seal selection. Governs all other factors. Shown in FEET PER MINUTE AS SLOW, MODERATE, HIGH.			
FPM	Slow	0 to 800	0 to 1000	0 to 1000
	Moderate	800 to 1500	1000 to 2000	1000 to 2000
	High	1500 to 2000	2000 to 3000	2000 to 3000
TEMPERATURE	Limits shown are points where sealing material or medium sealed becomes ineffective. For sealing under extreme temperature conditions, special compounds can be employed.			
LIMITS °F.	Continuous	−65° +200°	−65° +225°	−65° +225°
	Intermittent	−65° +225°	−60° +250°	−60° +250°
PRESSURE	Conventional oil seals are not pressure seals. Where pressures above those shown exist, special seals should be employed or pressure against sealing lip relieved.			
MAXIMUM PSI	Slow	15	10	10
	Moderate	10	7	7
	High	5	5	5
SHAFT FINISH	Fineness and type of finish, direction and spiral of finishing marks and leads as well as RMS value affect sealing. Polished or ground finishes with concentric finish marks are preferred.			
MAXIMUM MICRO INCHES	Slow	25	25	25
	Moderate	20	20	20
	High	20	20	20
SHAFT HARDNESS	Although shafts as soft as cold rolled steel can be sealed successfully, hardness of C20 Rockwell or greater is preferred. Fluid starvation, abrasives and high surface speeds require hard shafts.			
SUGGESTED ROCKWELL	Abrasives	above C-45	above C-45	above C-45
	No abrasives	above B-80	above B-80	above B-80
SHAFT TO BORE MISALIGNMENT	Fixed misalignment of center of shaft rotation with bore center. Concentrates wear at one side of seal. Becomes more severe as speed increases.			
TOTAL INDICATOR	Slow	.010	.015	.015
	Moderate	.005	.010	.010
	High	.005	.010	.010
SHAFT RUN-OUT	Oscillating non-concentricity between shaft and bore centers (also eccentricity or shaft whip). Run-out should be kept to absolute minimum; creates difficult sealing problem.			
TOTAL INDICATOR RPM	0-800	.010	.025	.025
	800-2200	.005	.020	.020
	2200-4200	.003	.015	.015

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio

MINNESOTA MR RUBBER

FACTS for FILING on SILICONE PARTS


• TEMPERATURE STABILITY FROM —130° F to 500° F
• RESISTS OZONE AND WEATHER AGING
• LOW COMPRESSION SET
• CHEMICAL AND OIL RESISTANT
• LOW WATER ABSORBTION RATE
• HIGH DIELECTRIC STRENGTH

NEW HORIZONS for INDUSTRY

Minnesota Rubber injection molded silicone parts enable designers to improve operating characteristics of scores of rubber components such as automatic transmission seals, bellows, diaphragms, electric insulators and molded parts subjected to unusually tough operating conditions.

The exclusive method of injection molding insures absolute uniformity of parts giving the user consistent performance characteristics. Thus the engineer can accurately predict performance for his unit.

Minnesota Rubber produces O-Rings, Quad Rings, custom molded parts and extrusions out of silicone. In addition you can specify silicone rubber for PROTOTYPES BY KOTOKAST. No matter what your requirements, you can be sure of getting tops in quality and service from Minnesota Rubber.

TYPICAL PROPERTIES OF SILICONE RUBBER

- Temperature range..... —130 to 500° F
- Tensile strength, psi..... 600 to 900
- Tear strength, lb/in..... 40 to 75
- Elongation, %..... 150 to 300
- Compression set, % @ 300 F..... 15 to 40
- Hardness range, durometer..... 20 to 90
- Dielectric strength, volts/mil..... 400 to 500
- Oil resistance, depending on oil..... good to excellent

FOR MORE INFORMATION AND A COPY OF THE SILICONE RUBBER HANDBOOK... WRITE MINNESOTA MR RUBBER

NFPA

WRITE ON YOUR LETTERHEAD FOR A FREE COVER TO BIND YOUR "FACTS FOR FILING" PAGES

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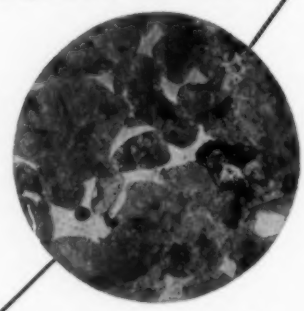
CIRCLE NO. 202 READER SERVICE CARD

Quality of GRAMIX® precision parts insured by metallurgical control in the laboratory *proven by performance on the job!*

Photomicrograph of a section of an inferior powder metallurgy part that has been improperly sintered. Structure is composed of cementite and ferrite.



Photomicrograph of an internally sound GRAMIX part shows the fine grain structure of tough, shock-resistant pearlite.

To assure the dependable performance of GRAMIX powder metallurgy parts in actual operation, the United States Graphite Company combines exacting laboratory tests and rigid production controls to insure the quality of every GRAMIX part. Through the use of the metallograph, for example, GRAMIX engineers can check the internal structure of a part. A comparison of the photomicrographs shown above readily shows the sound under-the-surface quality of a GRAMIX part as opposed to the poor internal composition of an improperly sintered part. In the photomicrograph at the top, notice the cementite between the ferrite grain boundaries. This cementite will tend to break up and rupture under shock. The surface of the material is decarburized and only remnants of pearlite remain. *This condition is due entirely to the lack of adequate sintering control!*

The photomicrograph of the GRAMIX part at the bottom shows a fine grain pearlite structure that's tough, strong and wear resisting. Absolute sintering control along with precise metallurgical control in the laboratory is utilized by The United States Graphite Company to positively assure quality GRAMIX parts.

Write today for these helpful engineering manuals. Engineering Bulletin No. 18 covers design and metallurgical requirements and alloy selection of GRAMIX bearings. No. 19 contains facts about GRAMIX Machine Parts and No. 21 contains general information on GRAMIX products from Powder Metallurgy. Get your copies now.

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